ESTIMATING SHEET AND RILL EROSION

The Revised Universal Soil Loss Equation Version 2 (RUSLE2) is used to estimate interrill (sheet) and rill erosion caused by water. RUSLE2 is an upgrade of the text-based RUSLE DOS version 1. It is a computer model containing both empirical and process-based science in a Windows environment that predicts rill and interrill erosion by rainfall and runoff. The USDA-Agricultural Research Service (ARS) is the lead agency for developing the RUSLE2 model. The ARS, through university and private contractors, is responsible for developing the science in the model and the model interface.

RUSLE2 was developed primarily to guide conservation planning, inventory erosion rates and estimate sediment delivery. Values computed by RUSLE2 are supported by accepted scientific knowledge and technical judgment, are consistent with sound principles of conservation planning, and provide a good basis for developing conservation plans for controlling sheet and rill erosion.

RUSLE2 evolved from a series of previous erosion prediction technologies. The original Universal Soil Loss Equation (USLE) was an empirically based model and was limited in its application to conditions where experimental data were available for deriving factor values. A major advancement in RUSLE1 was the use of subfactor relationships to compute C factor values from basic features of cover-management systems. While RUSLE1 retained the basic structure of the USLE, process-based relationships were added where empirical data and relationships were inadequate, such as computing the effect of strip cropping in conjunction with modern conservation tillage systems.

Like RUSLE 1, RUSLE2 uses the basic structure of the USLE; however, soil loss calculations are done on a daily basis through multiple iterations of the model to obtain the final estimated annual soil loss. Improved cover-management subfactor relationships are used in RUSLE2, a new ridge subfactor has been added, and sediment deposition equations extended to consider sediment characteristics and how deposition changes these characteristics. RUSLE2 also includes new relationships for handling residue, including resurfacing of residue by implements like field cultivators.

The major visible change in RUSLE2 is its new, modern graphical user interface which makes the model easier to use. However, it is an extremely powerful tool in terms of the information that it displays and the types of situations that it can represent.

Currently, RUSLE2 is not part of the Standard Load for USDA-NRCS computer. A copy of the installation file and instructions for installing RUSLE2 are located on the O:\ drive (O:\Rusle2\Rusle2 Installation Program). Alternatively, the installation program and instructions for installing it can be downloaded from the national RUSLE2 website.

http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

This is the official NRCS version of the RUSLE2 Model and is the only version of RUSLE2 to be used for official purposes by NRCS field offices.

The NRCS also developed and maintains the database components on this site. These components comprise the Official NRCS RUSLE2 Database. Databases developed using
these components are the only databases to be used for official purposes by NRCS field office employees.

Localized RUSLE2 databases have been developed by the State Agronomist and are also located on the O:\ drive (O:\Rusle2\NRD Databases).

**ESTIMATING EPHEMERAL GULLY EROSION**

Annual soil loss predictions for planning purposes are now made with the Revised Universal Soil Loss Equation (RUSLE2), the Wind Erosion Equation (WEQ), or both. RUSLE2 accounts only for sheet and rill erosion. When needed, an additional value may be included to account for erosion from large gullies using the method described in the next section. Soil loss caused by seasonal, concentrated flow channels or ephemeral gully erosion may be estimated using the method below:

This procedure should only be applied on soils with slopes of 3% or greater.

For computing ephemeral erosion, refer to Table 3 below and map (FOTG SECTION I – Erosion Prediction), "Ephemeral Erosion Codes."

1. Use the map to determine the correct code for your county.
2. Match the code number for your county with the correct values in Table 3. For instance, Buffalo County is in a Code 3 area, which has a value from Table 3 of 30 percent for untreated land and 5 percent for treated.
3. Compute the RUSLE2 value for sheet and rill erosion.
4. Multiply the RUSLE2 value just computed times the percentages from Table 3 to arrive figures for ephemeral erosion in before and after situations.

**Table 3:** Percentage of sheet & rill erosion used to estimate ephemeral erosion in T/Ac/Yr likely to result on a given field.

<table>
<thead>
<tr>
<th>EECM*</th>
<th>Untreated Land</th>
<th>After Treatment**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>

* Ephemeral Erosion Code Map
** One or more of the following practices must be planned: Terrace, Diversion, Stripcropping, Contour Buffer Strip or Grassed Waterway. If cropland is converted to perennial vegetation (range or pasture planting), the After Treatment percentage will always equal zero.

The appropriate value from Table 3 should be multiplied by the RUSLE2 value calculated for sheet & rill erosion for a given field.
Example: An 80-acre field in Otoe County is having conservation measures installed, which will include a terrace system. Examination of the soil survey shows a 15-acre patch of IIIe soil on the area to be terraced.

1. Checking the "Ephemeral Erosion Codes" map, Otoe County is in Code area 4.
2. For purposes of this example, RUSLE2 factors are assumed on the 15-acre patch of IIIe soil, which will equal an erosion rate of 20 tons per acre. That means total annual erosion for this patch is:

   \[ 20 \text{ tons/year} \times 15 \text{ acres} = 300 \text{ tons/year}. \]

3. From erosion Code 4, on untreated land the ephemeral erosion is 40 percent of sheet and rill. Therefore,

   \[ 300 \text{ t/yr} \times 40\% = 120 \text{ tons/year of ephemeral erosion on the untreated land} \]

4. Table 3 shows erosion "after treatment" of 10 percent in Code 4. Recomputed the RUSLE2 (with any changed factors) for the IIIe land after terracing. Determine sheet and rill erosion, multiply times the area, and then multiply the result times the 10 percent remaining.

Recomputed RUSLE2 (Assumed for this example) = 4 tons/acre/yr. 4 tons/acre \times 15 \text{ acre} = 60 \text{ tons/year erosion}. 60 \text{ tons/year} \times 10 \text{ percent (from Table 3)} = 6 \text{ tons/year ephemeral erosion after treatment}.

For the entire 15-acre patch of land, the amount of soil saved due to reduction of ephemeral erosion is 120 tons/yr - 6 tons/yr = 114 tons/yr. This is in addition to any savings realized through reduction of sheet and rill erosion.

Questions on ephemeral erosion and its computation should be directed to the Resource Conservation Staff.
ESTIMATING CHANNEL EROSION

Channel erosion is a general term for erosion occurring when water moves within a stream, gully, or other defined channel. Erosion can occur along banks, channel bottoms, and in gully headcuts. Similar erosion can occur along roads (in ditches and road cuts) and on construction sites. The Gully Erosion Calculation Spreadsheet found in eFOTG Sec. IV, C. Tools, can be used to calculate volume of gully erosion or it can be done manually using the procedure described below. These procedures are designed for field office use on individual fields and relatively small-scale operations. For larger situations, the Resource Conservation Staff is available for consultation and technical assistance.

The method used in these cases is to compute the volume of material eroded and the time period involved. Volume is determined by finding the three dimensions of length, width, and depth. Width in this case is called lateral recession, and refers to how much the bank has receded or cut back. For example, an eroding section of streambank 300 feet long (length) and six feet deep (depth) is cutting back or receding at a rate 0.5 feet per year (width). The volume voided annually is:

\[ 300' \times 6' \times 0.5' = 900 \text{ ft}^3/\text{yr} \]

In cases of gully erosion, the volume voided from the gully sides is usually computed separately from the gully head cut. This is because headcutting usually occurs at a faster rate than lateral recession. The two volumes are then added to give a total volume voided. For eroding stream channels, if the channel bed is eroding and the channel is deepening, it should likewise be computed as a separate volume and added to the bank erosion.

For measuring voiding along streambanks or in gullies, refer to the attached Tables 1 and 2 and the map entitled, "Channel Erosion Code Areas."

1. Use the map to determine the correct code number for your county, and then turn to the sheet "Clues for Recognizing Gully and Streambank Erosion."

2. Decide if your erosion is "slight," "moderate," or "severe" in intensity. Refer to Table 1, where matching the code number with intensity will result in a lateral recession rate. For example, a Code 2 combined with "slight" intensity results in a range of lateral recession between 0.05 ft/yr and 0.2 ft/yr. You then choose an appropriate value within these limits for your particular field situation.

3. Volume voided can now be computed by multiplying eroding bank length x bank height x selected lateral recession rate. Answer will be in cubic feet per year, as shown by the previous example in paragraph two.

4. Refer now to Table 2, "Suggested General Weight/Volume by Soil Type." This will give a volume/weight value for the soil type appropriate to your situation. This value is then multiplied by the volume to give pounds eroded annually. The answer is divided by 2,000 to convert to tons per year eroded.
Example:

A cultivated field selected for conservation treatment contains a gully, which measures 400 feet long and averages 6 feet deep. The location is Cass County, on an upland slope. Field inspection of the gully reveals a total from both sides of 300 feet of eroding bank (200' from one side, 100' from the other). The overfall or headcut is 10 feet wide, 5 feet deep, and receding at the rate of 2 feet/year.

Looking at the sheet "Clues for Recognizing Gully and Streambank Erosion" and comparing to this field situation, the intensity of erosion is determined to be "slight."

1. From the map (FOTG Section I Erosion Prediction) "Channel Erosion Code Areas," Cass County is in the Code 3 area. Going to Table 1, Code 3 with an intensity of "slight" allows a range between 0.1 and 0.3 ft/yr. for lateral recession. A specific rate of 0.2 ft/yr. is selected.

2. Volume voided can now be computed.
   A) Side walls
   
   $300' \times 6' \times 0.2' = 360 \text{ ft}^3/\text{yr}$

   B) Headcut
   
   $10' \times 5' \times 2' = 100 \text{ ft}^3/\text{yr}$.

   C) Total Volume Voided
   
   $360 \text{ ft}^3/\text{yr} + 100 \text{ ft}^3/\text{yr} = 460 \text{ ft}^3/\text{yr}$

3. Convert to tons, using the value of 90 lbs./ft$^3$ for "silty or clayey upland" from Table 2:

   $460 \text{ ft}^3 \times 90 \text{ lbs.}/\text{ft}^3 = 41,400 \text{ lbs} / 2,000 \text{ lbs/ton} = 20.7$ or 21 tons/yr eroded
CLUES FOR RECOGNIZING GULLY AND STREAMBANK EROSION

Slight - There are patches of bare bank, but lateral recession of the bank is not very obvious. It would be difficult to measure over a period of one or two years. Trees can be established within the gully or along the channel, and there is little or no overhang of vegetation at the top of the bank.

Gully headcutting is defined, but advancement is not obvious.

Moderate - Streambank erosion is characterized by bare sections of actively erosion banks. These sections may be continuous, or intermittent with stable bank sections. Gully erosion also shows similar activity, which can occur on one or both sidewalls. The headcut is well defined, bare, and steeply sloping or vertical. Headcutting rate shows visible advancement when compared with aerial photos of 3-5 years previous. There are freshly exposed tree roots, overhanging vegetation, and exposed cultural features such as drain pipe or fence posts. Changes in other cultural features adjacent to channels can be noted such as missing fence corners or realignment of roads and cropping patterns.

Severe - Streambank erosion is characterized by meandering streams having major washouts and block slumps in addition to the characteristics of moderate erosion. Alterations in cultural features are obvious, including deterioration of bridge abutments. Change of stream channel course is sometimes an indication of severe erosion. In many cases, severe localized bank erosion can result from channel straightening, both up and down stream from the straightened section.

Gully headcutting and lateral recession is indicated by raw, steep banks. Headcutting has obviously occurred since the previous year. Patches of recently eroded material can be temporarily deposited along the channel bottom.

Table 1. Gully Erosion – Suggested Lateral Recession Rates

<table>
<thead>
<tr>
<th>Lateral Rates of Recession (ft/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>
Table 2. Suggested General Weight/Volume by Soil Type

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Weight/Volume (lbs./ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silty or clayey alluvial</td>
<td>80</td>
</tr>
<tr>
<td>Silty or clayey upland</td>
<td>90</td>
</tr>
<tr>
<td>Sandy</td>
<td>100</td>
</tr>
<tr>
<td>Bedrock (siltstone, shale)</td>
<td>150</td>
</tr>
</tbody>
</table>