Interill Erosion
Interill Detachment and Sediment Delivery to Rills

\[ D_i = K_{iadj} \cdot I_e \sigma_{ir} \cdot SDR_{RR} \cdot F_{\text{nozzle}} \cdot (R_s / w) \]

- **\( D_i \)** = Interill sediment delivery rate (kg s\(^{-1}\)m\(^{-2}\))
- **\( K_{iadj} \)** = Adjusted Interill Erodibility (kg s m\(^{-4}\))
- **\( I_e \)** = Effective Rainfall Intensity (m s\(^{-1}\))
- **\( SDR_{RR} \)** = Interill Sediment Delivery Ratio
- **\( F_{\text{nozzle}} \)** = Sprinkler Nozzle Energy Factor
- **\( R_s \)** = Rill spacing (m)
- **\( w \)** = Rill width (m)
Adjusted Interill Erodibility (*Cropland Adjustments*)

\[ K_{\text{adj}} = K_{ib} (CK_{\text{ican}})(CK_{\text{idr}})(CK_{\text{ilr}})(CK_{\text{isc}})(CK_{\text{isi}})(CK_{\text{ift}}) \]

\( K_{ib} = \) baseline interill erodibility (kg s m\(^{-4}\))
\( CK_{\text{ican}} = \) canopy adjustment factor
\( CK_{\text{idr}} = \) ground cover adjustment factor
\( CK_{\text{idr}} = \) dead root adjustment factor
\( CK_{\text{ilr}} = \) live root adjustment factor
\( CK_{\text{isc}} = \) sealing and crusting adjustment factor
\( CK_{\text{isi}} = \) slope adjustment factor
\( CK_{\text{ift}} = \) freeze and thaw adjustment factor
Adjusted Interill Erodibility
(Rangeland Adjustments)

\[ K_{iadj} = K_{ib} \left( RK_{icov} \right) \left( RK_{ift} \right) \]

- \( K_{ib} \) = baseline interill erodibility (kg s m\(^{-4}\))
- \( RK_{icov} \) = interill surface and canopy cover adjustment factor
- \( RK_{ift} \) = interill freeze and thaw adjustment factor
$SDR_{RR}$ – Interill Sediment Delivery Ratio

Based on Tables 8.4 & 8.5 in Foster (1982), “Chapter 8” in ASAE Monograph #5

1. Interill roughness factor computed as a function of Random Roughness
2. Determine Sediment Delivery Ratio for each of the 5 WEPP size classes
3. Obtain a weighted average SDR using the values from the individual classes
Rill Detachment
Rill Detachment Equation

\[ D_f = K_{\text{adj}} (\tau_f - \tau_c)(1 - G/T_c) \]

- \( D_f \) = Rill Detachment Rate (kg s\(^{-1}\) m\(^{-2}\))
- \( K_{\text{adj}} \) = Adjusted Rill Erodibility (s m\(^{-1}\))
- \( \tau_f \) = Flow Shear Stress (Pa)
- \( \tau_c \) = Critical Flow Shear Stress
- \( G \) = Sediment Load (kg s\(^{-1}\) m\(^{-1}\))
- \( T_c \) = Transport Capacity (kg s\(^{-1}\) m\(^{-1}\))
**Adjustments to Rill Erodibility Parameters**

Cropland:
- Incorporated Residue ($K_r$)
- Live and Dead Roots ($K_r$)
- Sealing and Crusting ($K_r \& \tau_c$)
- Freeze and Thaw ($K_r \& \tau_c$)
- Random Roughness ($\tau_c$)

Rangeland:
- Freeze and Thaw ($K_r \& \tau_c$)
Rill Deposition Equation

\[ D_f = (\beta V_{\text{eff}} / q)[T_c - G] \]

- \( D_f \) = rill deposition rate (kg s\(^{-1}\) m\(^{-2}\))
- \( \beta \) = rainfall turbulence factor
- \( V_{\text{eff}} \) = effective fall velocity (m s\(^{-1}\))
- \( q \) = flow discharge (m\(^3\) s\(^{-1}\) m\(^{0.1}\))
- \( T_c \) = Transport Capacity (kg s\(^{-1}\) m\(^{-1}\))
**Sediment Transport Capacity**

\[ T_c = k_t (\tau_f)^{1.5} \]

- \( T_c \) = Transport Capacity in Rills (kg s\(^{-1}\) m\(^{-1}\))
- \( k_t \) = Transport Coefficient computed based on modified Yalin equation
  
  \( (m^{0.5} \ s^2 \ kg^{-0.5}) \)

- \( \tau_f \) = Flow shear stress acting on soil (Pa)
Modifications to Yalin Equation

• Based on extensive testing of the WEPP model for a large range of different soil types and measured field erosion data.
• First modification is to use a weighted average of the sediment transport capacity for each particle size class.
• Second modification adjusts total transport when sand fraction is >0.50:

\[ tcadjf = 0.3 + 0.7 e^{-12.52 \times (\text{sand} - 0.5)} \]
Watershed Erosion
Channel Hydrology & Hydraulics

• Channel runon and runoff situations
• SCS triangular synthetic hydrographs
• 2 methods to computer peak runoff
  – Modified Rational
  – CREAMS method
• Spatially varied flow equations to simulate effects of backwater
**Governing Equation**

*(Channel Erosion)*

\[
dG/dx = D_L + D_F
\]

- **G** = Sediment Load in channel (kg s\(^{-1}\) m\(^{-1}\))
- **x** = Segment downslope distance (m)
- **D\(_L\)** = Lateral Sediment Inflow (kg s\(^{-1}\) m\(^{-2}\)) from adjacent hillslopes or ponds
- **D\(_F\)** = Detachment or Deposition by Flow (kg s\(^{-1}\) m\(^{-2}\))
Channel Detachment

• Detachment Capacity: \( D_c = K_{ch}(\tau_{ave} - \tau_{cr}) \)

• When Sediment Load is below Transport Capacity and average channel flow shear stress exceeds critical shear stress, active Channel Erosion occurs (before the depth of the channel reaches nonerodible layer):

\[
E_{ch} = w_{ch} K_{ch} (\tau_{ave} - \tau_{cr})
\]

• Once a nonerodible layer is reached, the channel widens and erosion decreases.
Channel Deposition

• When Sediment Load in the Channel exceeds Transport Capacity, Deposition is predicted to occur.

• Computes deposition of individual particle size classes, using CREAMS model approach.

• If Sediment Load of all classes is greater than Transport Capacity for each class, this equation is used: $D_F = \left(\frac{v_f}{q_w}\right)[T_c - G]$
Surface Impoundments

• Can simulate various types:
  – Farm ponds
  – Culverts
  – Filter fences
  – Check dams

• Based upon more complete CSTRS model (Wilson and Barfield, 1984)

• Assumes a single continuously stirred reactor
Surface Impoundments

The hydraulic simulation section

• Performs a direct numerical integration of an expression of continuity

• An adaptive time step is utilized which increases the time step when the inflow and outflow rates are relatively constant

• A temporary file of the predicted outflow hydrograph is created
Surface Impoundments

The sedimentation section

• Determines the amount of sediment deposited and the outflow concentration for each time step

• Conservation of mass and overflow rate concepts are utilized

• Two calibration coefficients are used to account for impoundment geometry, hydraulic response, and stratification