Runoff

- SCS Method
  - Designed for small scale watersheds (agricultural)
  - Designed for watersheds with topography
  - Accounts for land use characteristics
  - Accounts for soil conditions
- Rational Method
  - Lumped parameter model
  - Requires calibration

Soil Moisture and Infiltration
**Darcy Flux and Infiltration**

- The Darcy Flux is given by
  \[ q = -K \frac{dh}{dy} \quad (11.1) \]

- The head is defined as the soil suction head plus the gravitational head
  \[ h = \psi + y \quad (11.2) \]

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**Infiltration**

- Through substitution the Darcy Flux is
  \[ q = -K \frac{d}{dy} (\psi + y) \quad (11.3) \]

- Using the chain rule, the Darcy Flux becomes
  \[ q = -K \frac{d\psi}{d\theta} \frac{d\theta}{dy} - K \quad (11.4) \]

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**Infiltration**

- Soil diffusivity can be defined to be
  \[ D = K \frac{d\psi}{d\theta} \quad (11.5) \]

- The Darcy Flux becomes
  \[ q = -D \frac{d\theta}{dy} - K \quad (11.6) \]
From the chain rule the Darcy Flux equation becomes Richard’s Equation for soil moisture
\[
\frac{\partial \theta}{\partial t} = -\frac{\partial q}{\partial y} = D \frac{\partial^2 \theta}{\partial y^2} + K \tag{11.7}
\]

When both the soil diffusivity and the hydraulic conductivity are constant, irrespective to soil moisture Richard’s Equation simplifies
\[
\frac{\partial \theta}{\partial t} = D \frac{\partial^2 \theta}{\partial y^2} \tag{11.8}
\]

Which can be solved as Horton’s Equation
\[
f(t) = f_c + \left(f_0 - f_c\right) \exp(-kt) \tag{11.9}
\]
Phillip’s Equation

- The cumulative infiltration is defined as

\[ F(t) = \int f(t) \, dt \]  
(11.10)

- Phillip solved the Richard's equation under less constrictive conditions.

\[ F(t) = St^{1/2} + Kt \]  
(11.11)

Phillip’s Equation

- Which gives the infiltration rate through differentiation

\[ f(t) = \frac{1}{2} St^{1/2} + K \]  
(11.12)

Green-Ampt Infiltration
Green-Ampt Infiltration

- From the plug-flow model, the iterative cumulative sum of infiltration is given by

\[ F(t) = K_i + \psi \Delta \theta \ln \left( 1 + \frac{F(t)}{\psi \Delta \theta} \right) \]  

(11.13)

- Which is required in the Green-Ampt infiltration model

\[ f(t) = K \left( \frac{\psi \Delta \theta}{F(t)} + 1 \right) \]  

(11.14)

The change in soil moisture is related to the effective porosity and the effective degree of saturation

\[ \Delta \theta = (1 - s_e) \theta_e \]  

(11.15)

<table>
<thead>
<tr>
<th>Soil class</th>
<th>Porosity</th>
<th>Effective porosity</th>
<th>Matric head</th>
<th>Hydraulic conductivity</th>
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The numbers in parentheses below each parameter are one standard deviation around the parameter.
Soil Infiltration

Application rate influences both the ponding time and the cumulative infiltration without ponding.

- Slower application rates allow for greater amount to be infiltrated, and a longer time before ponding.
- Irrigation run times should not extend beyond the ponding time.