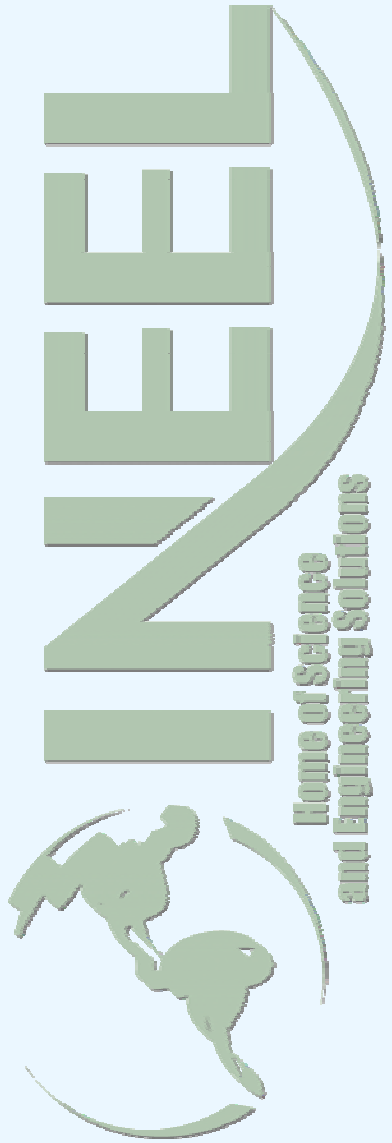

Idaho National Engineering and Environmental Laboratory

Overland Flow on Landfill Covers

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Mark Ankeny, Alva Parsons, & Jirka Simunek

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Balancing of Overland Flow

Increasing cover slope to reduce infiltration

against

Erosion on the landfill surface

Modeling of overland flow

Most models use the infiltration method (Runoff = precipitation rate – infiltration rate)
EPIC, CREAMS, VS2DI, VADOSE/W, HYDRUS 2D, UNSAT-H, SHAW2.3, SWIM, LEACHM, and TOUGH2

Some models that use SCS curve number method
EPIC, CREAMS, GLEAMS, and HELP3.07

None of these models adequately address runoff/runon – infiltration issues for landfill design

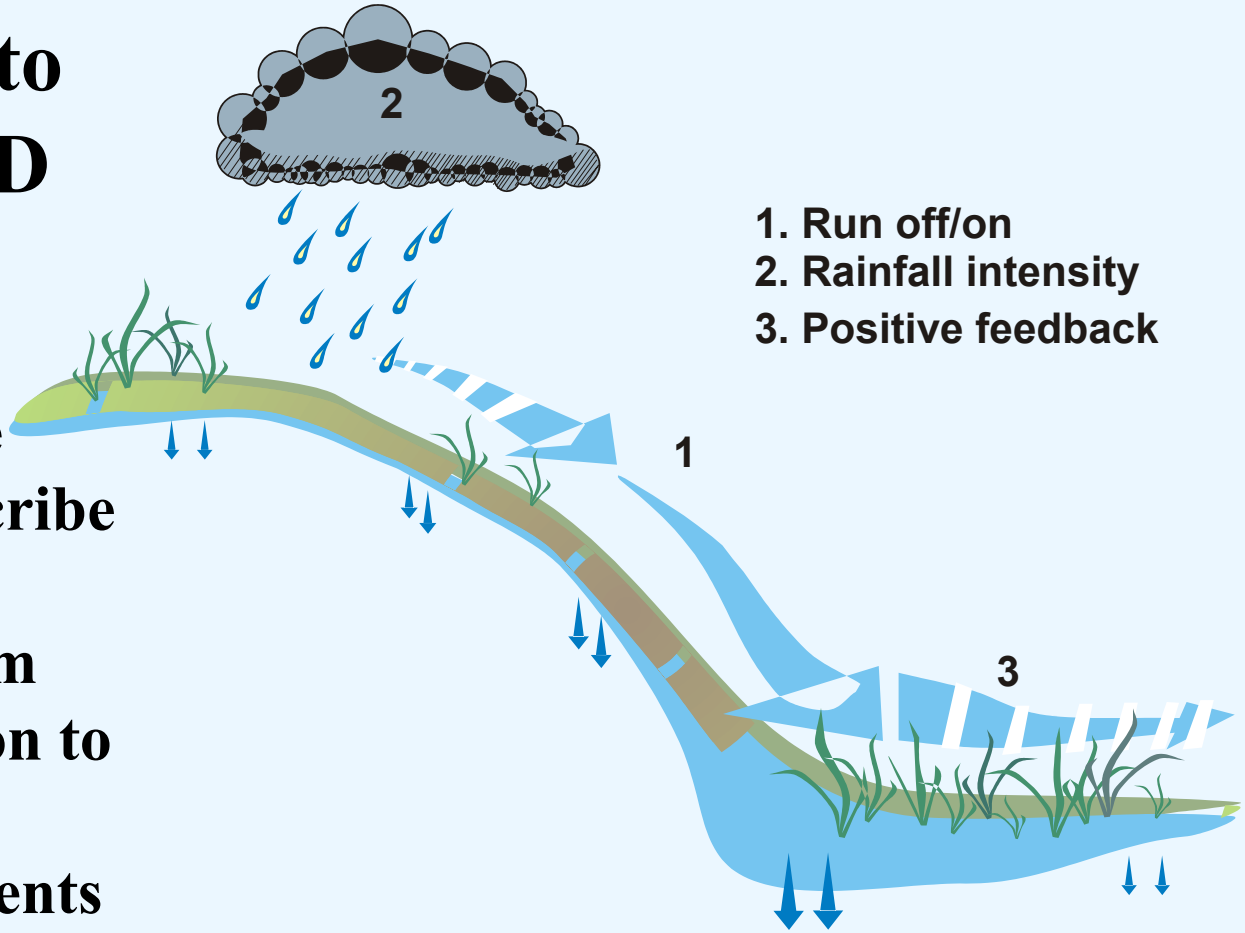
Factors affecting runoff

Soil	**Surface**	**Other Factors**
Infiltration rate	Surface crust	Rainfall intensity
Water content	Plant type	Storm timing
Particle size	Cover density	Storm duration
Frozen soil	Growth rate	Interception
Bulk density	Growth cycle	Surface depression
Clay mineralogy	Biomass	Litter
Macro porosity	Roughness	Land slope

(from ITRC, 2003)

Modifications to HYDRUS 2D

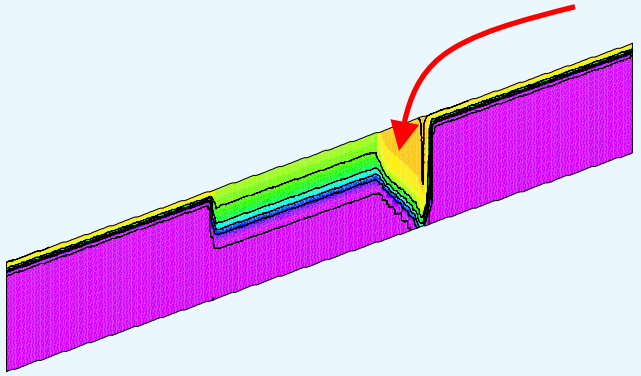
1) We added the Kinematic wave equation to describe overland flow
2) We added a storm intensity function to describe precipitation events
3) We incorporated a positive feed back loop



Overland Flow

Kinematic wave equation:

$$\frac{\partial h}{\partial t} + \frac{\partial Q}{\partial x} = q(x,t) \qquad Q = \alpha h^m$$

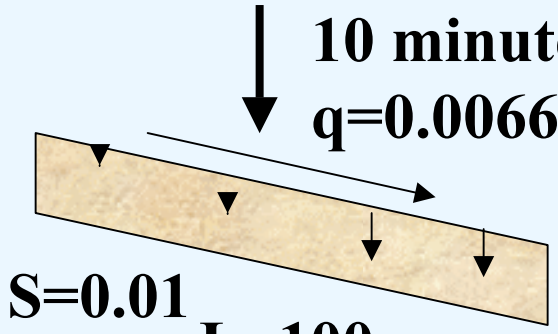


h **- unit storage of water (or mean depth),**
Q **- discharge per unit width,**
q**(*****x*****,*****t*****)- rate of local input, or lateral inflows (precip. - infiltration)**

Manning hydraulic resistance law:

$$\alpha = 1.49\frac{S^{1/2}}{n} \qquad \text{and} \qquad m = 5/3$$

n **- Manning's roughness coefficient for overland flow**
S **- slope**

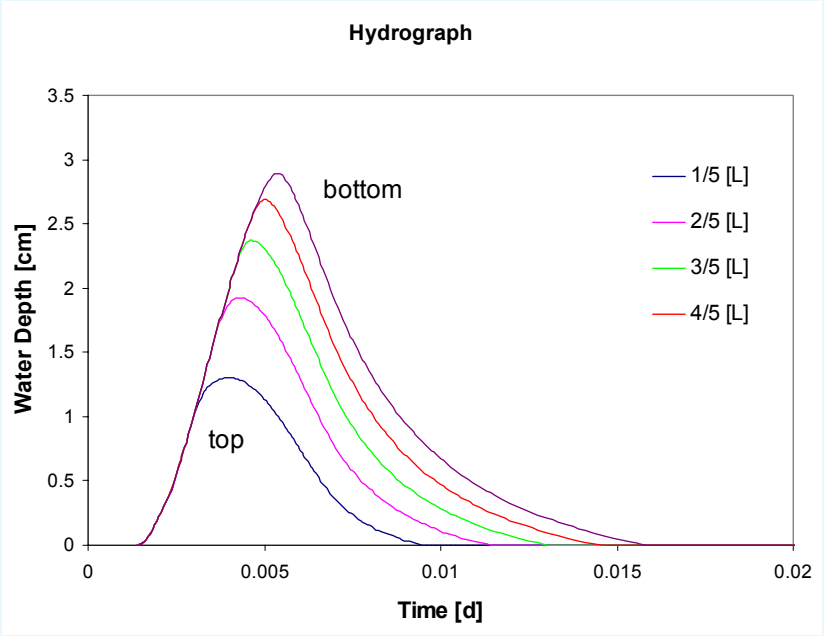


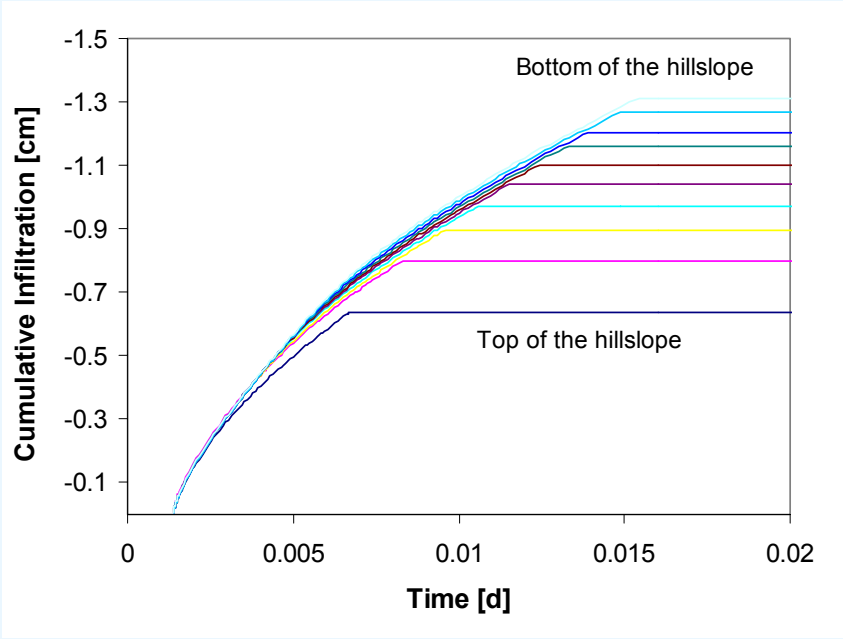
10 minutes rain (0.007 d),
q=0.00666 cm/s

S=0.01

L=100 m

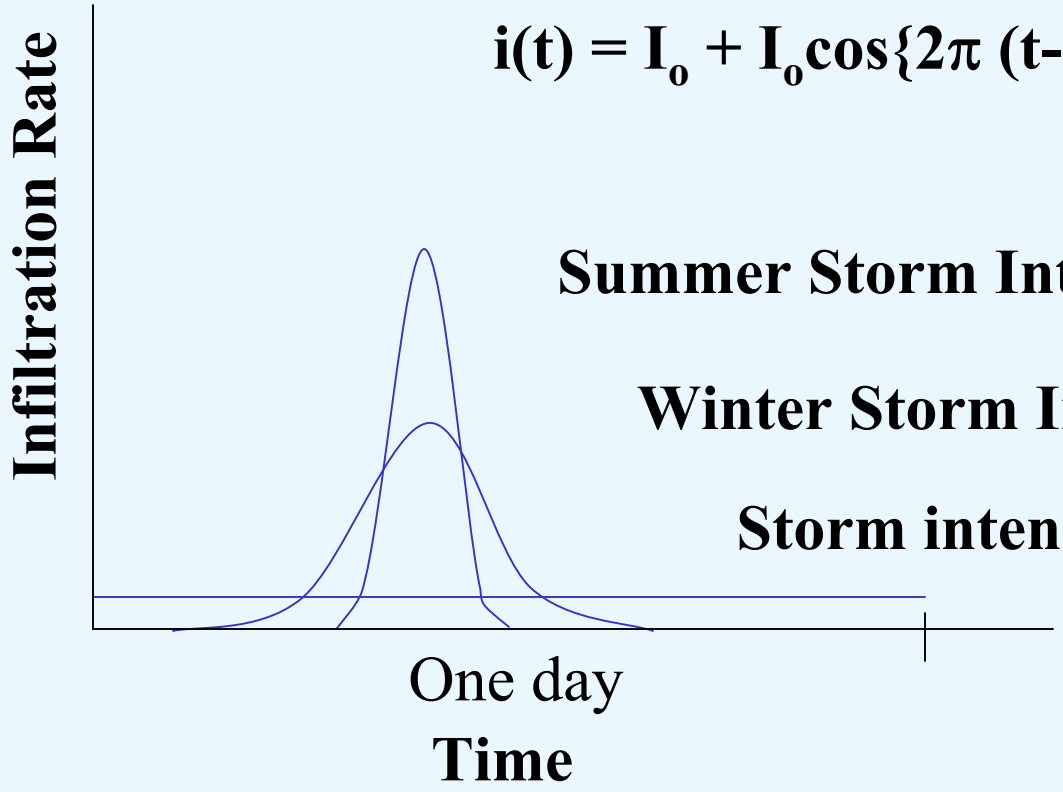
Loam
Ks = 0.0003 cm/s



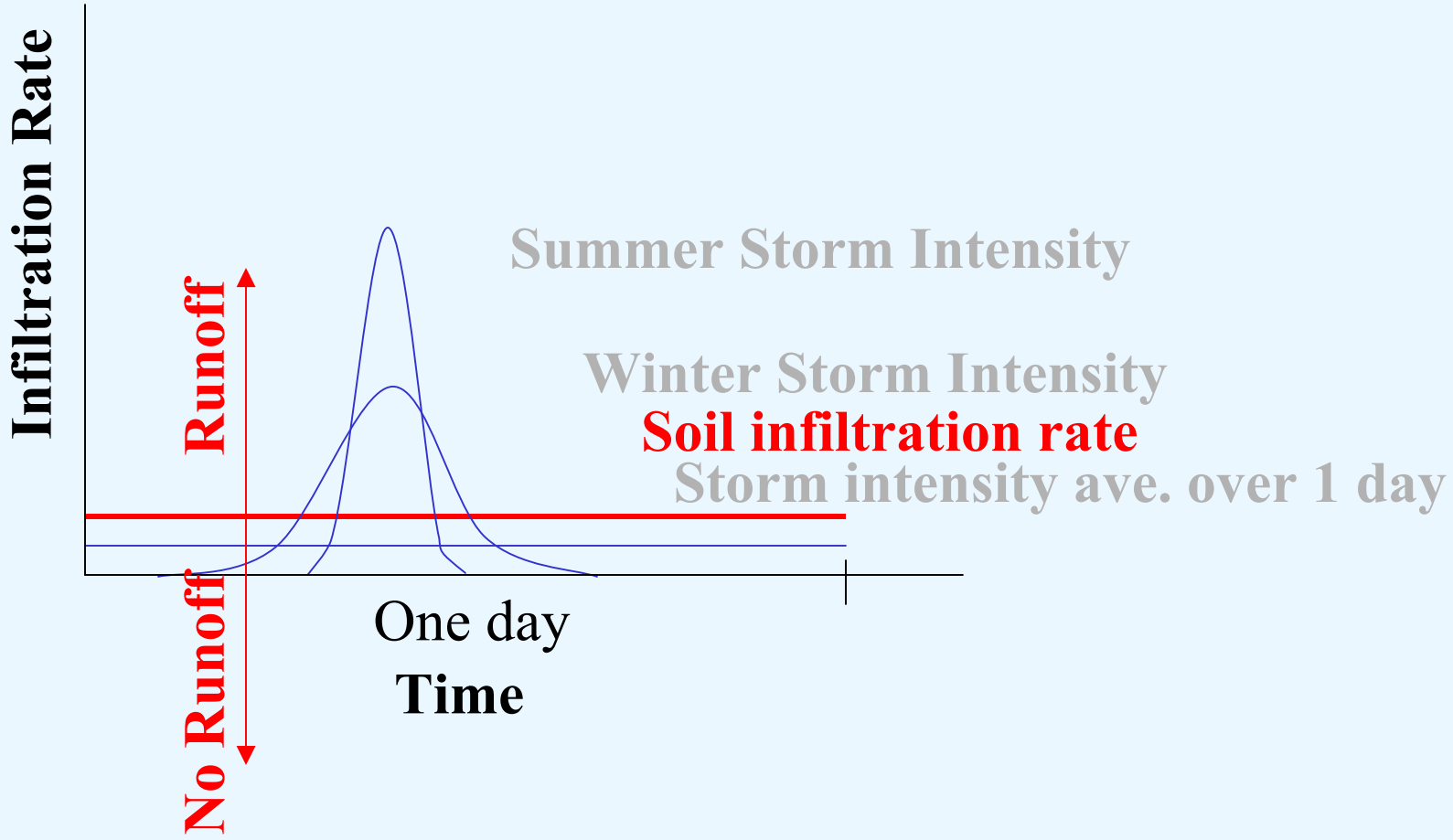


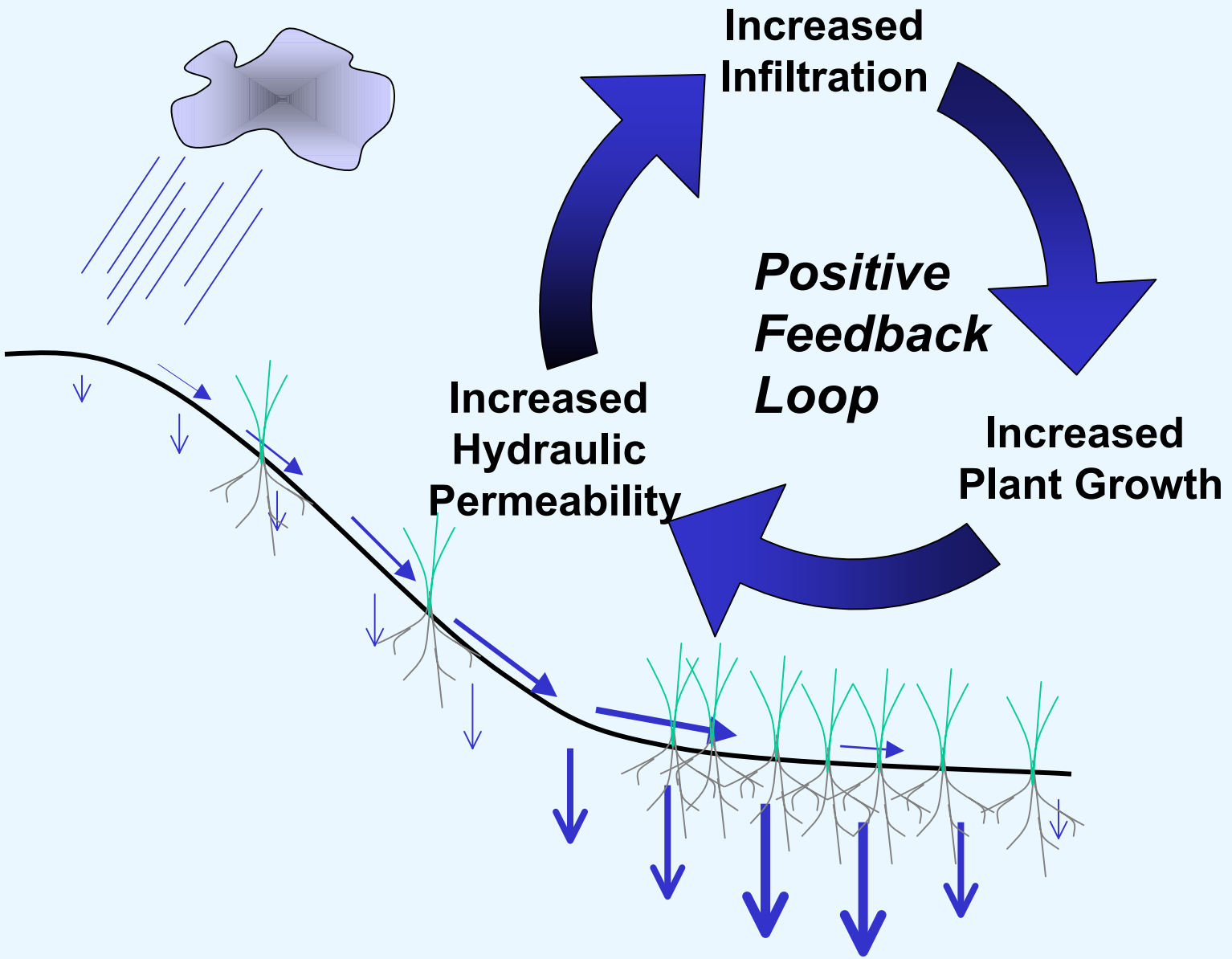
Runoff (storm intensity)

$$i(t) = I_o + I_o \cos\{2\pi\,(t-t_o)/\text{delta } t - \pi\}$$



Runoff (storm intensity)

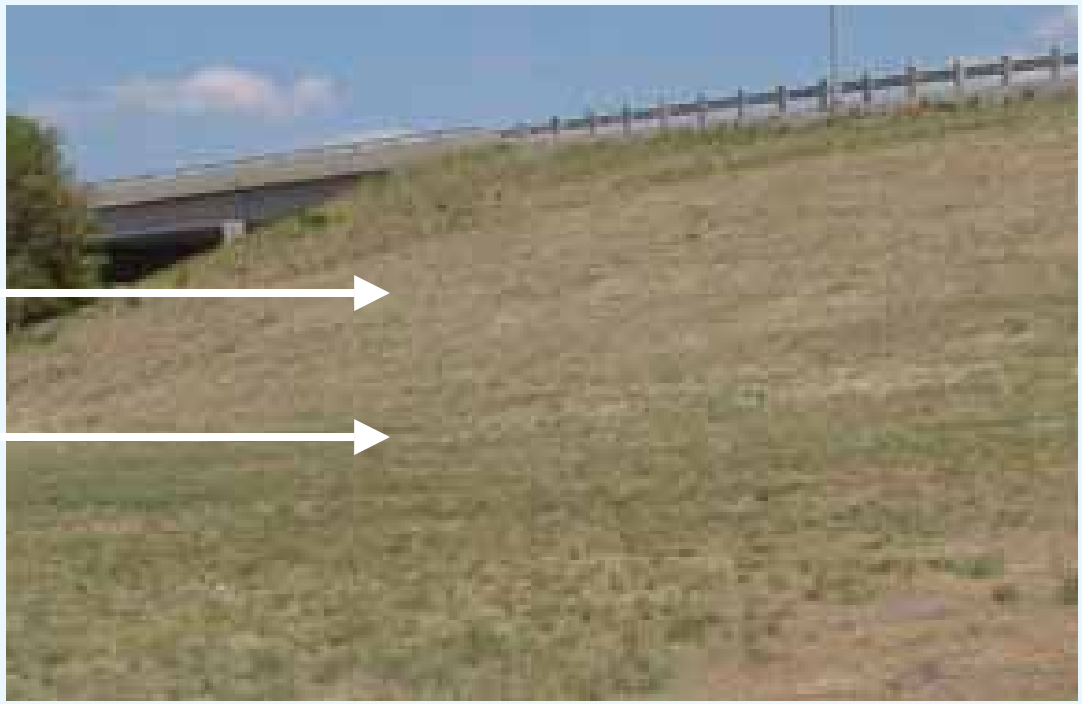


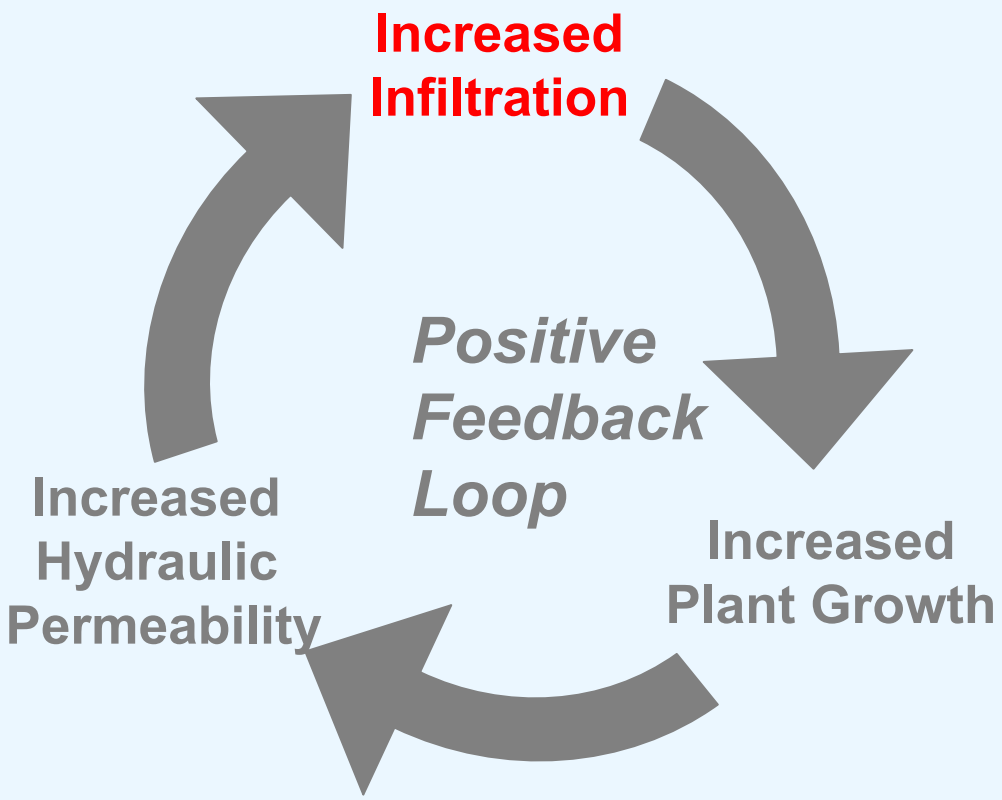

Increased
Infiltration
Positive
Feedback
Loop
Increased
Plant Growth
Increased
Hydraulic
Permeability

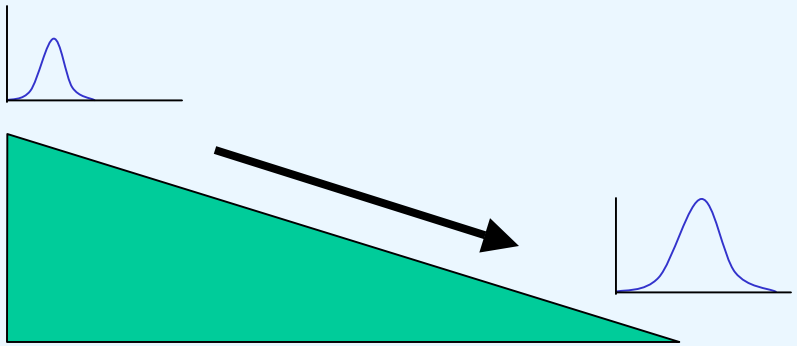
Qualitative proof

Less Green

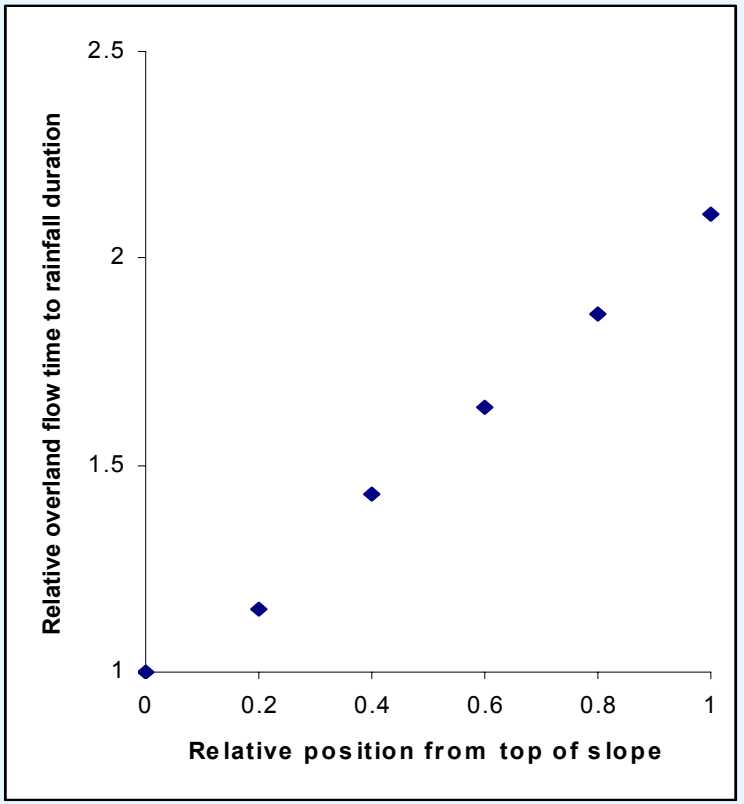
More Green

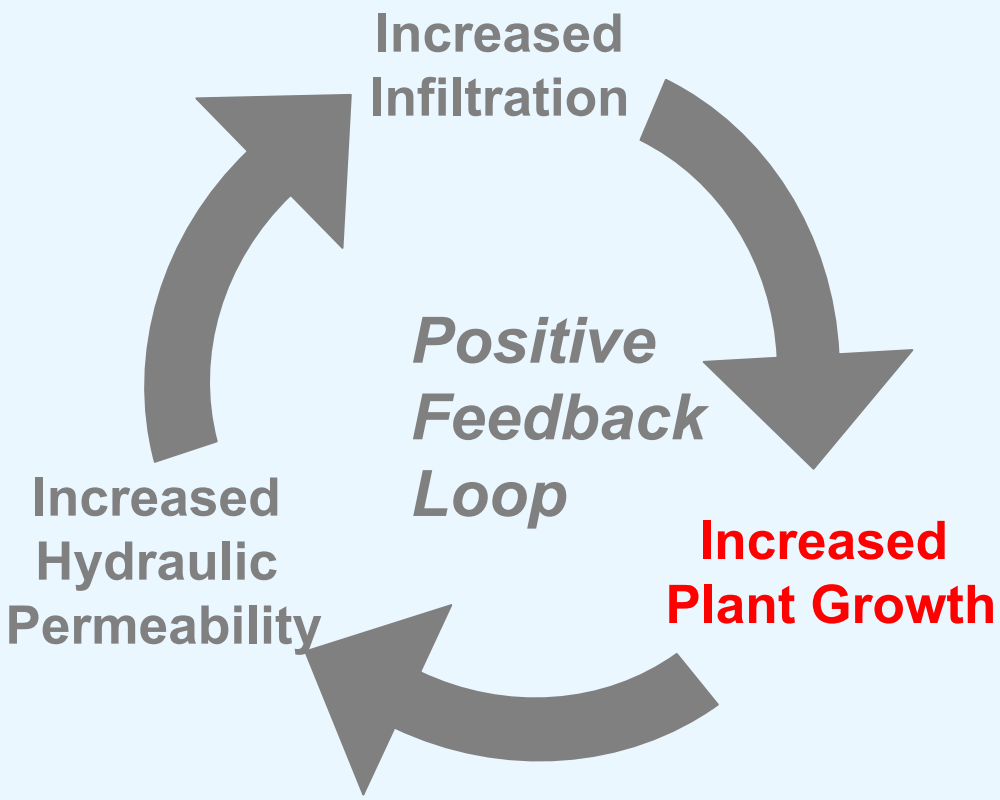






Infiltration is a function of the upper boundary condition in HYDRUS 2D as influence by the Overland Flow Modifications





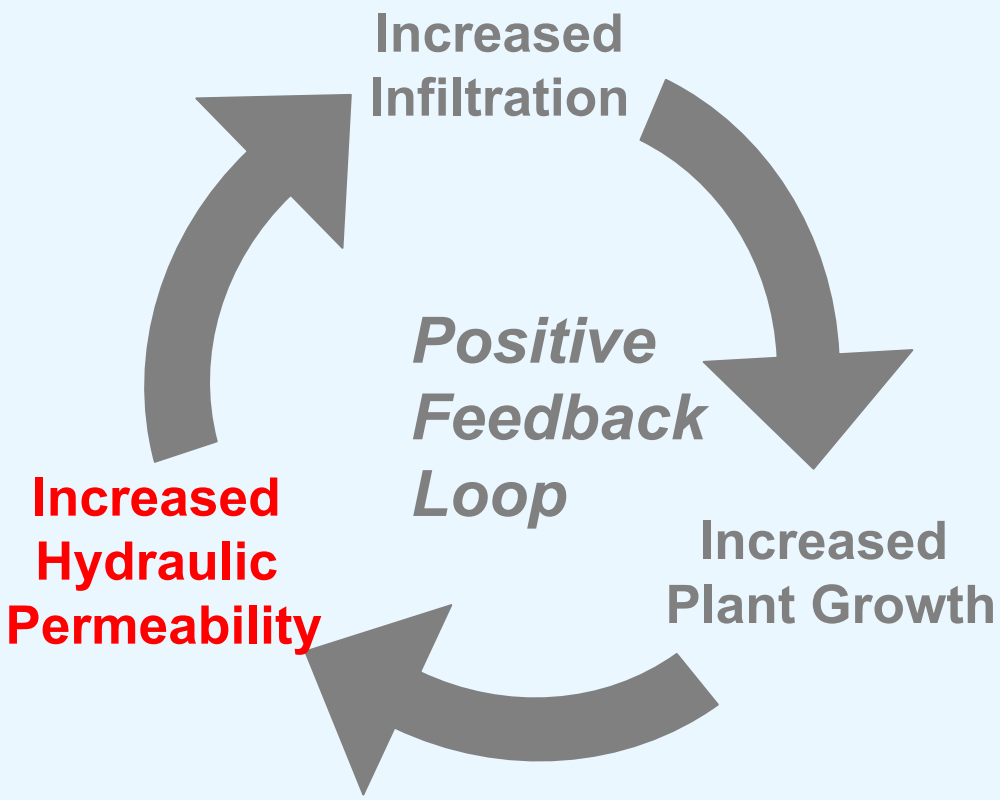
Plant growth is estimated using LAI as a measure. We assume that plant growth (i.e., LAI) is water limited in arid environments

First approach; LAI varies between zero and some max LAI value

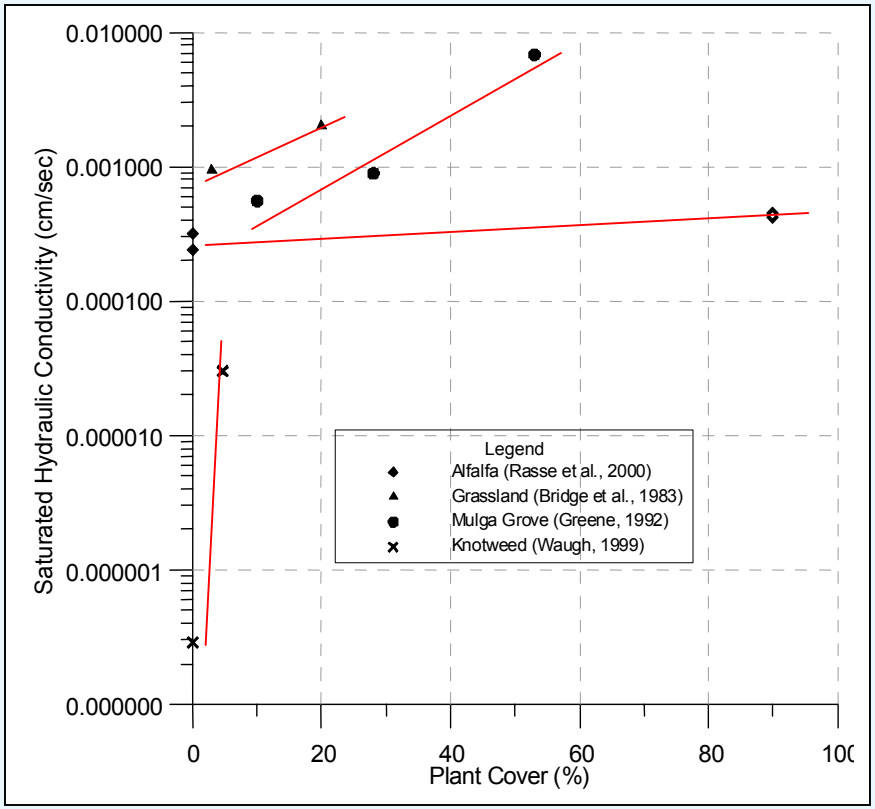
$LAI_{new} = \min(LAI_{max}; CumQ*bLAI)$

Newer approach; LAI has a growth and death term

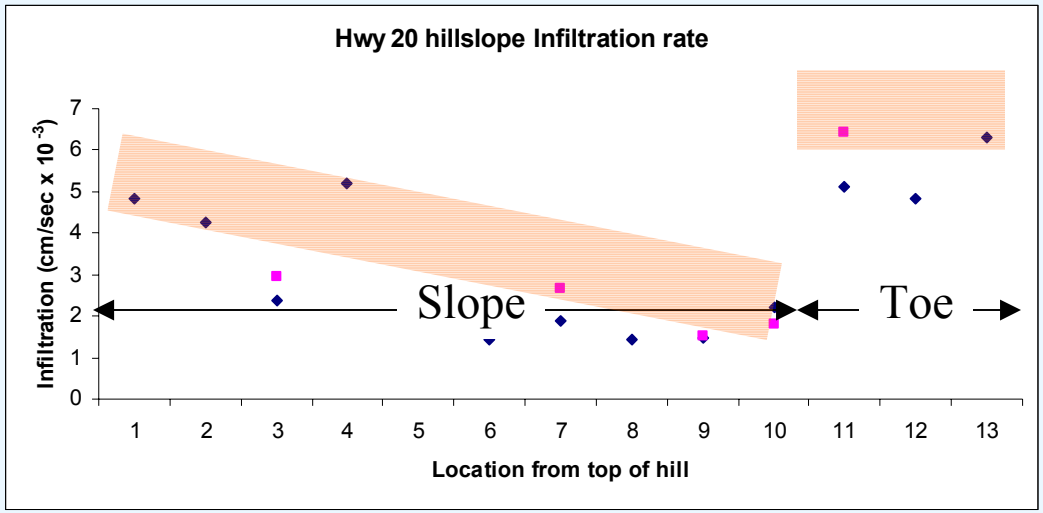
$LAI_{new} = LAI_{old} + \text{transpiration/water use efficiency term} - LAI_{max}/365$

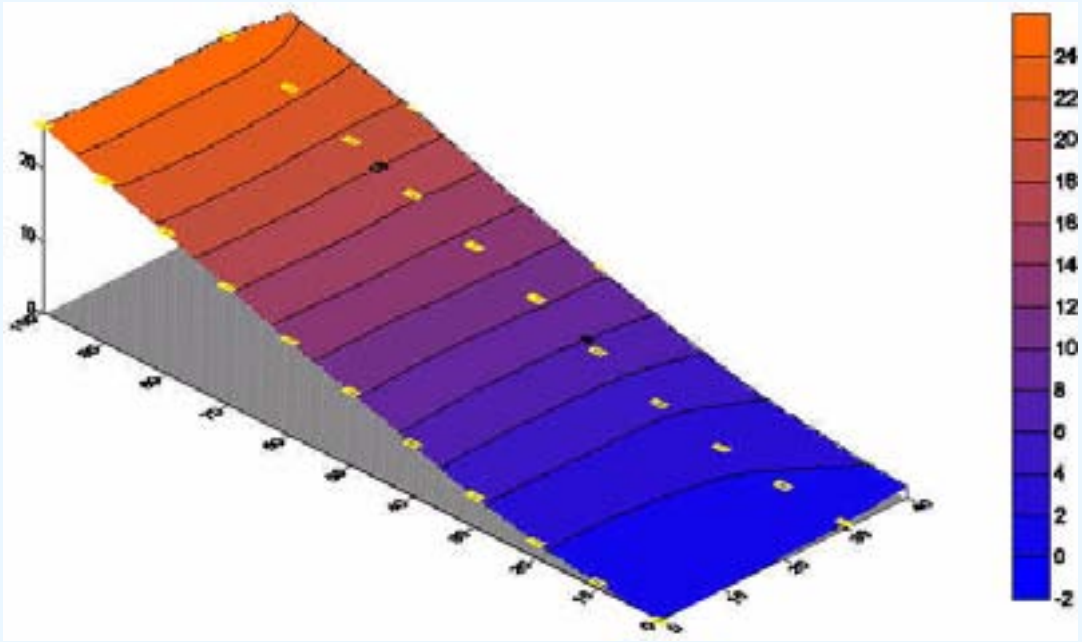


Saturated hydraulic conductivity is a function of the amount of plants on the surface.



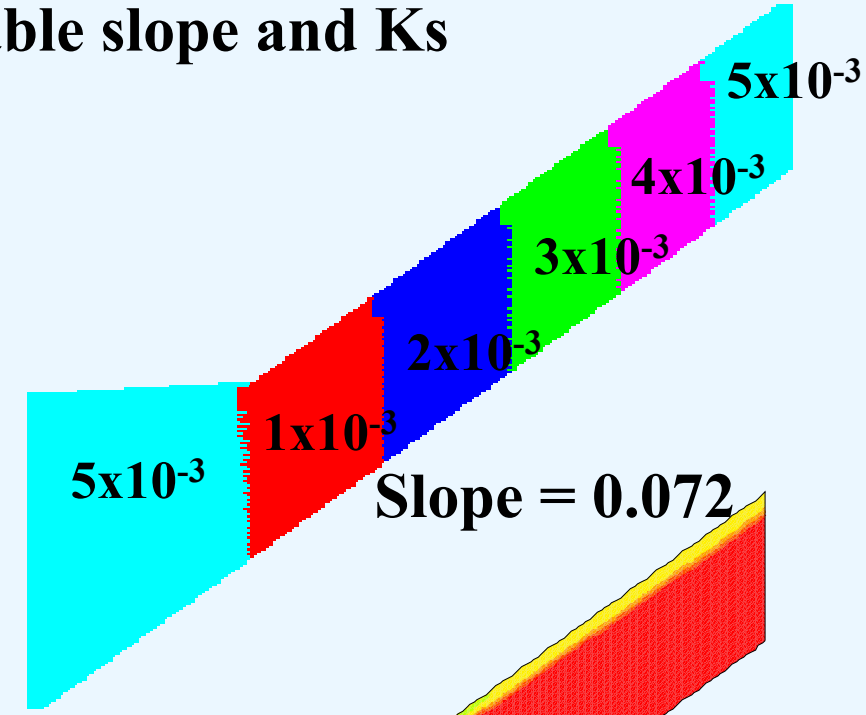
Infiltration (slope location)

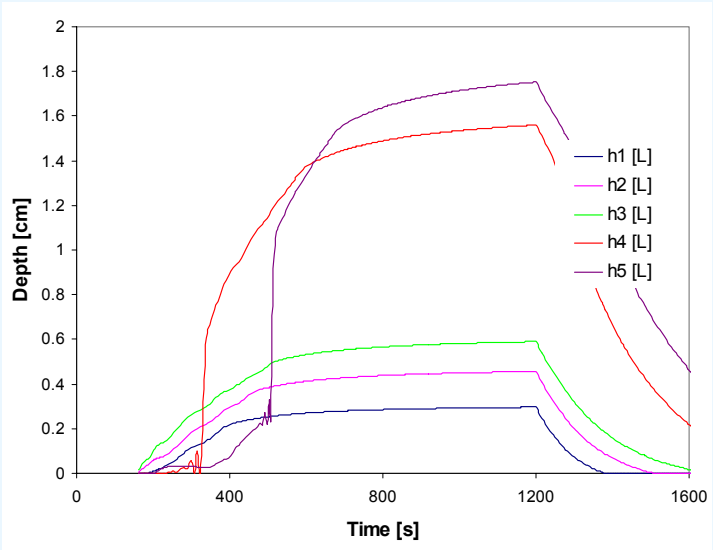


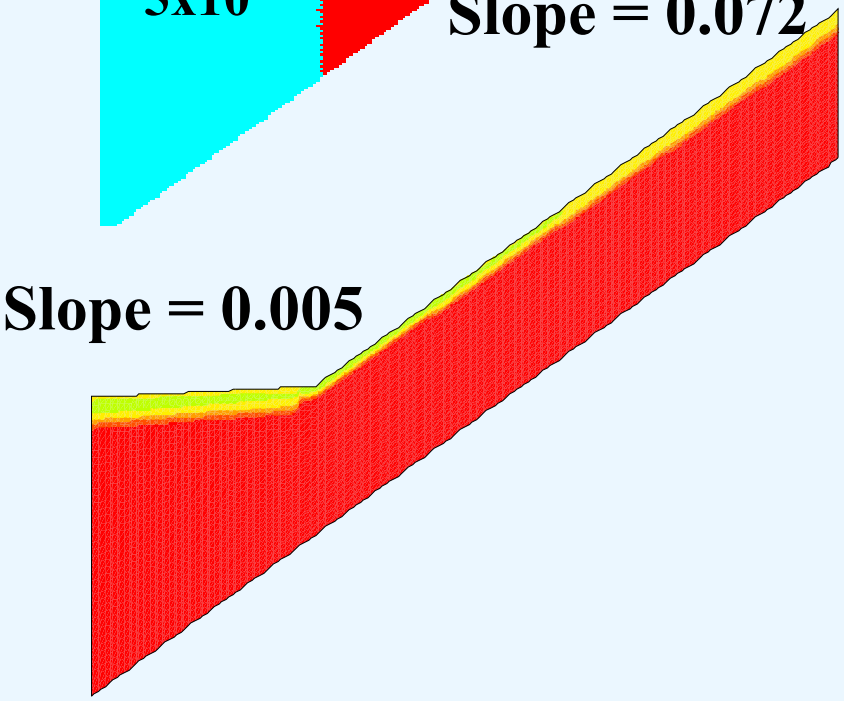


Field site example

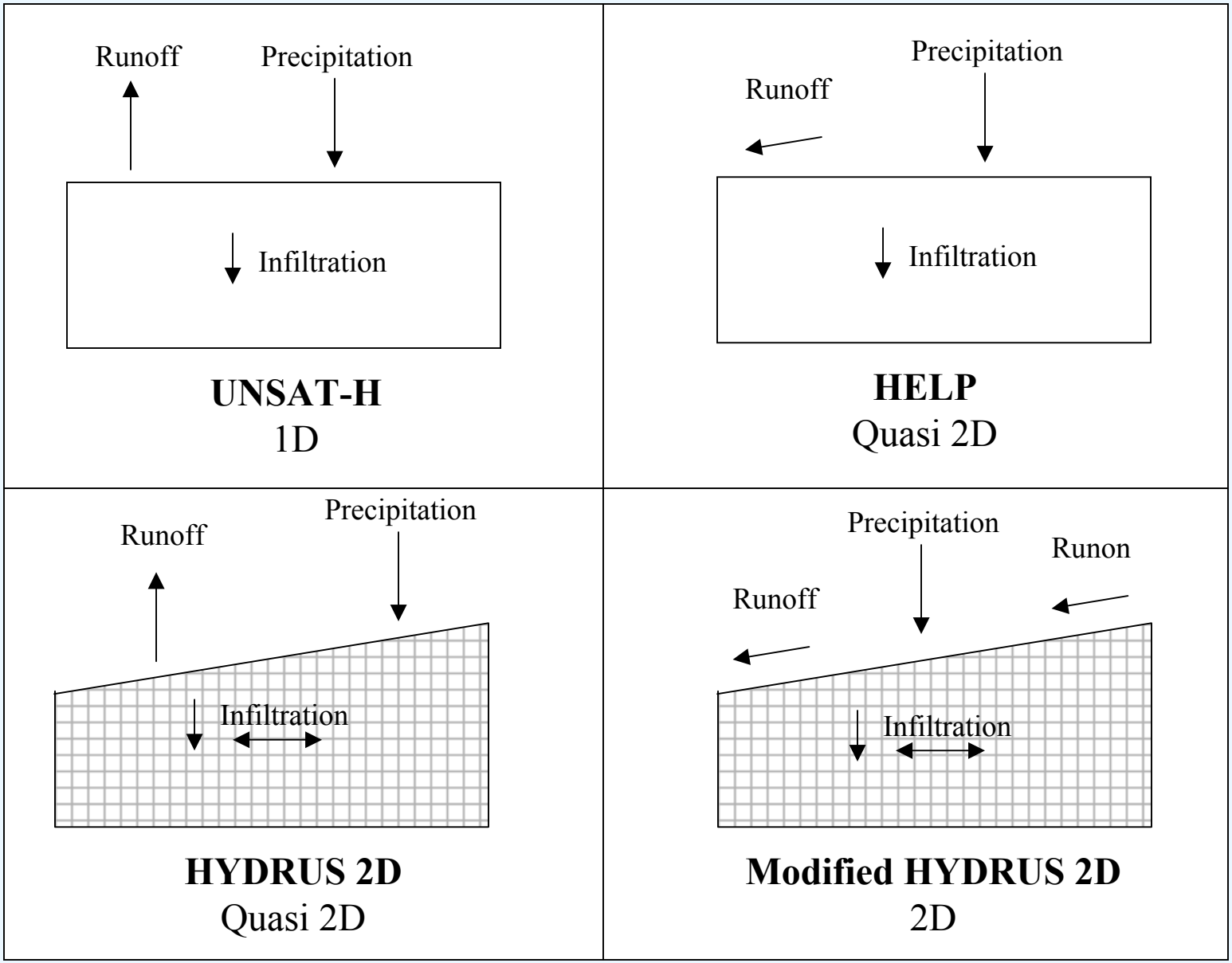
Variable slope and Ks







Landfill Cover Water Balance Method



Summary

- Overland flow
  - Spatial distribution of infiltration
  - Assist in erosion calculations
- Storm Intensity
  - Must have accurate description of storm intensity and duration
- Positive feed back
  - Landfills will have temporally varying properties