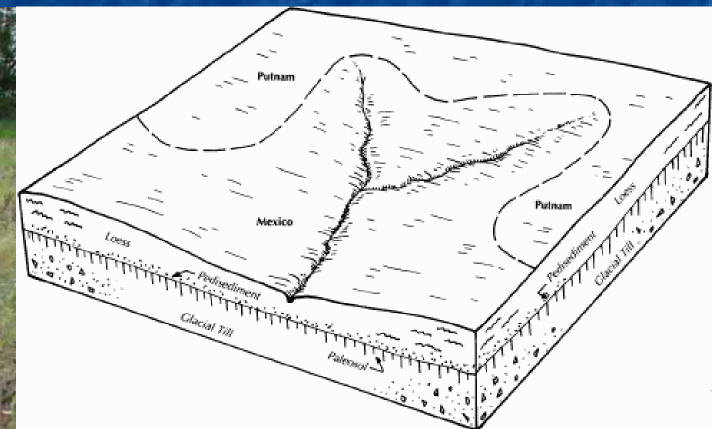
Soil Water Movement in SWAT

Simulation of Saturated Conditions and Lateral Flow

C. Baffaut, 2009 NWQ meeting, St Louis



Agricultural Research Service

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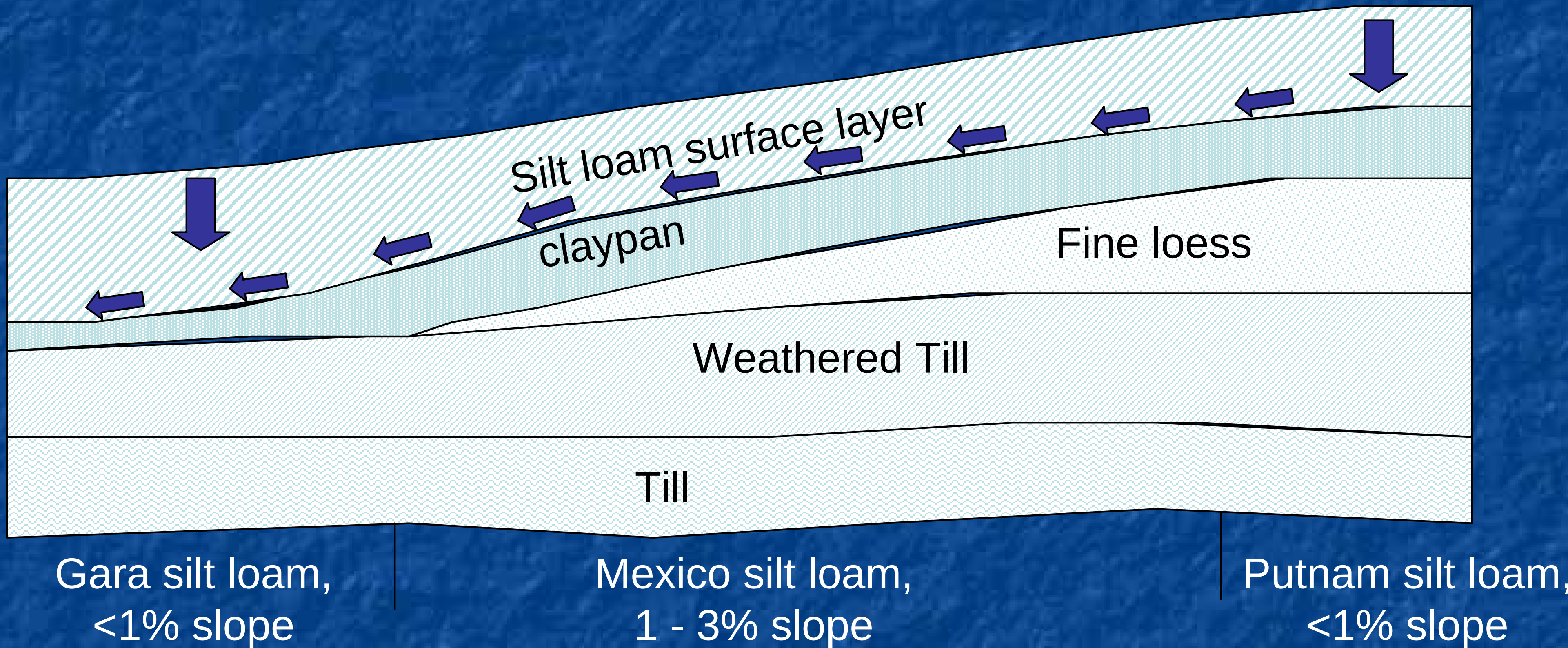
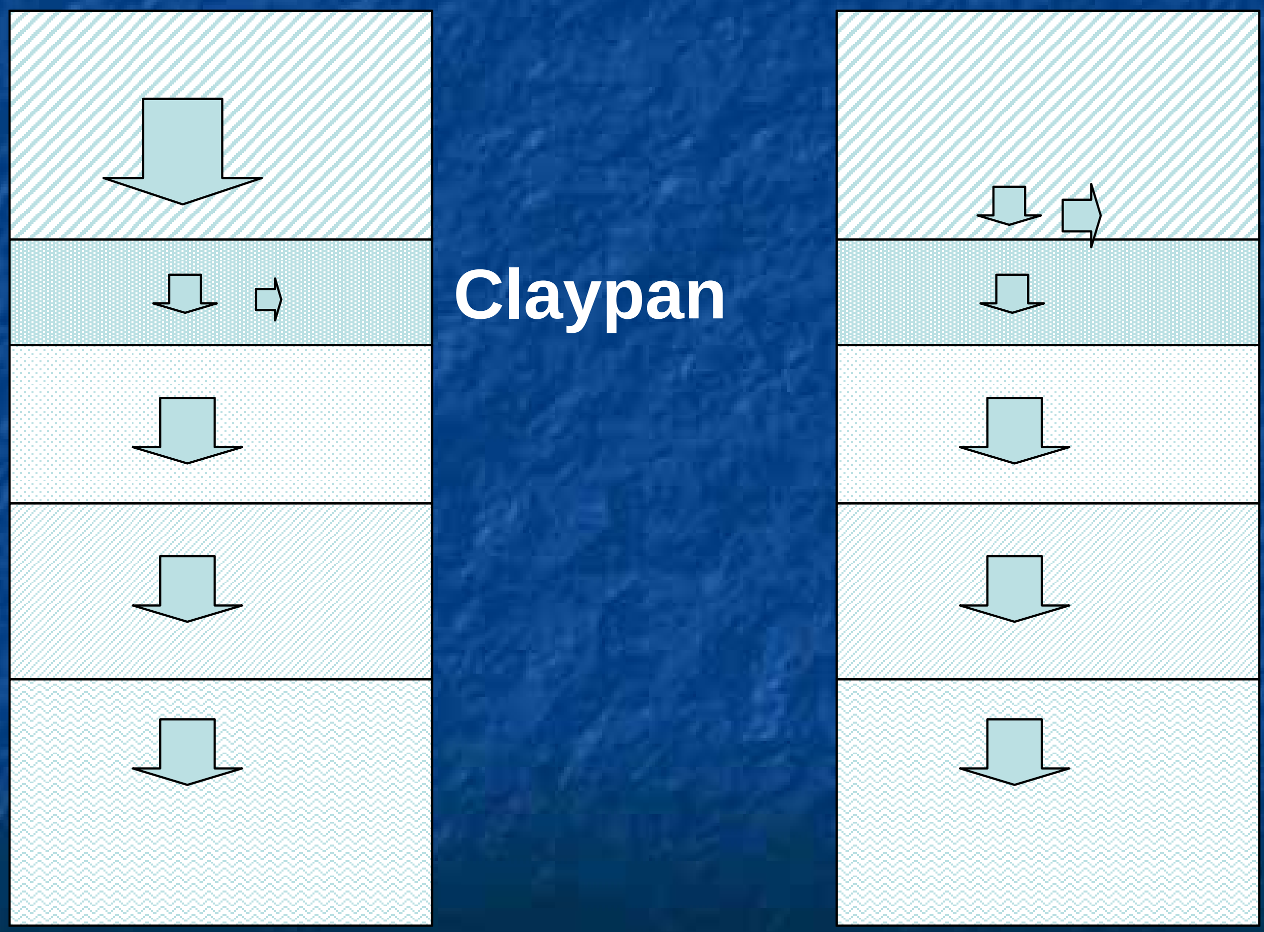
A typical claypan landscape



Schematic of a claypan landscape, after Jamison and Peters, 1967

How is water percolation simulated?

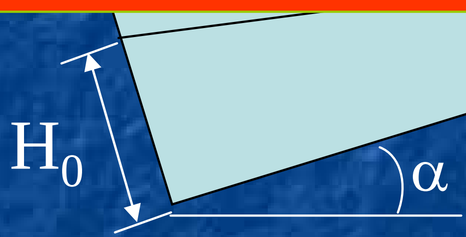


Current Formulation of Percolation

- Infiltration from one layer to the next is a function of the conductivity of the upper one.
- Infiltration is not limited by the saturation level of the layer below.
- Infiltration excess redistribution is calculated from the bottom of the profile.

Sloan and Moore, 1984
Currently in SWAT, WEPP, …

As the slope length increases, lateral flow decreases.
⟶ PROBLEM!



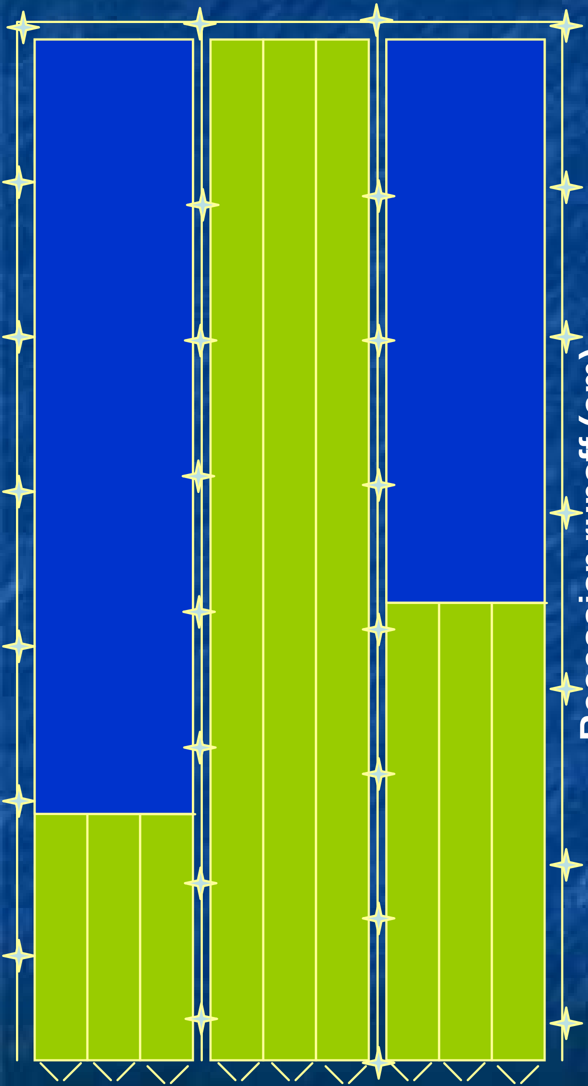
$$Q_{lat} = 0.024\left(\frac{2SW_{excess} \cdot K_{sat,ly} \cdot \sin\alpha}{\phi_{d}.L_{hill}}\right)$$

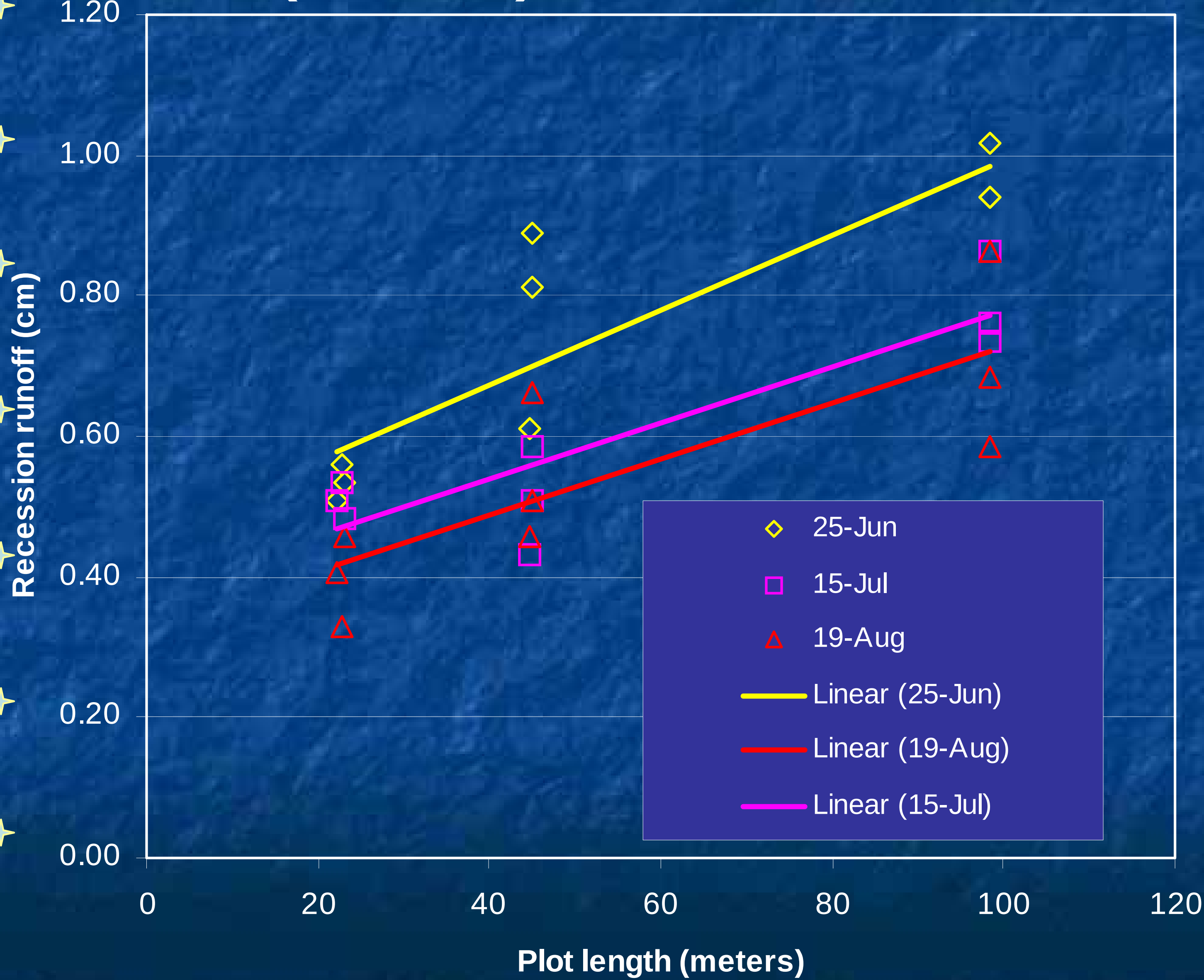
SW_{excess}: Drainable volume of water

$K_{sat,ly}$: Saturated conductiviy (mm/hr)

Φ_d : porosity

Jamison and Peters Experiment (1967)





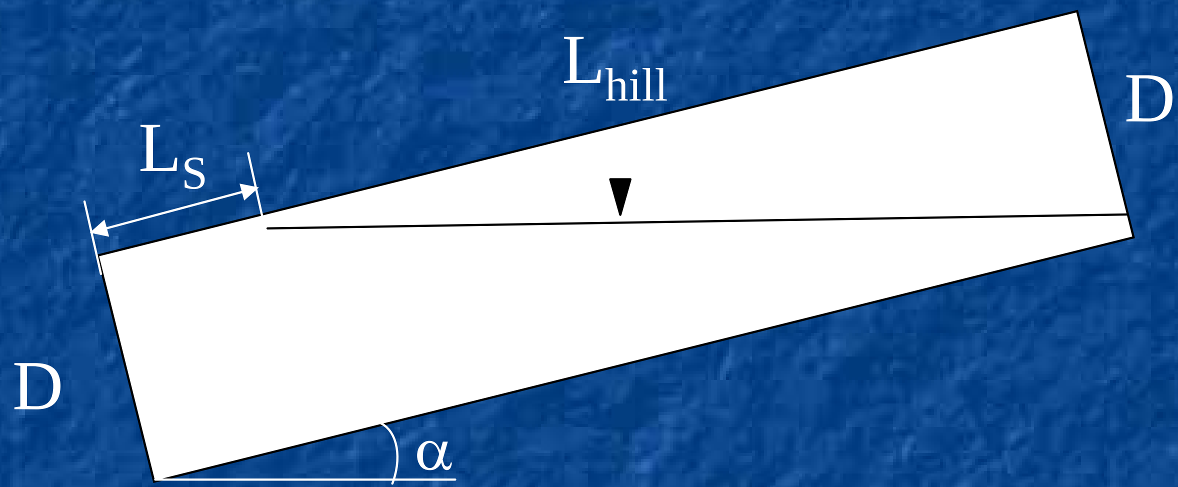
Lateral flow

- Drainage increases with:
  - Slope length
  - Slope steepness
  - Hydraulic conductivity

Proposed Vertical Percolation

- Ks = Ksat * f (water content) [SWRRB]
- Seepage restricted when layer below is saturated. [EPIC]
- Redistribution of soil moisture toward upper layers when soil water content > saturation

Proposed Formulation for Lateral Flow



Full formulation of Sloan and Moore (1984)

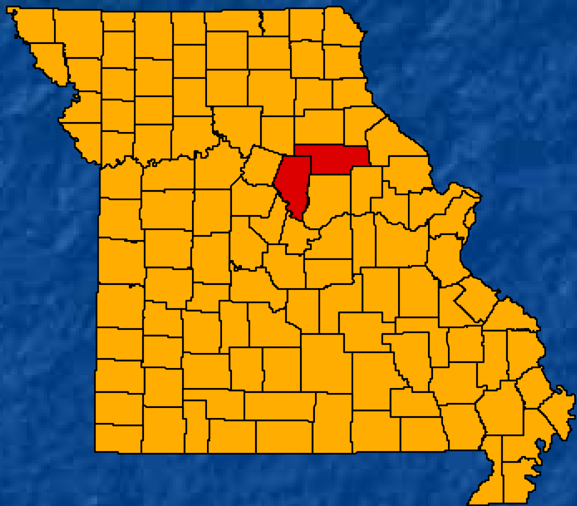
(1)

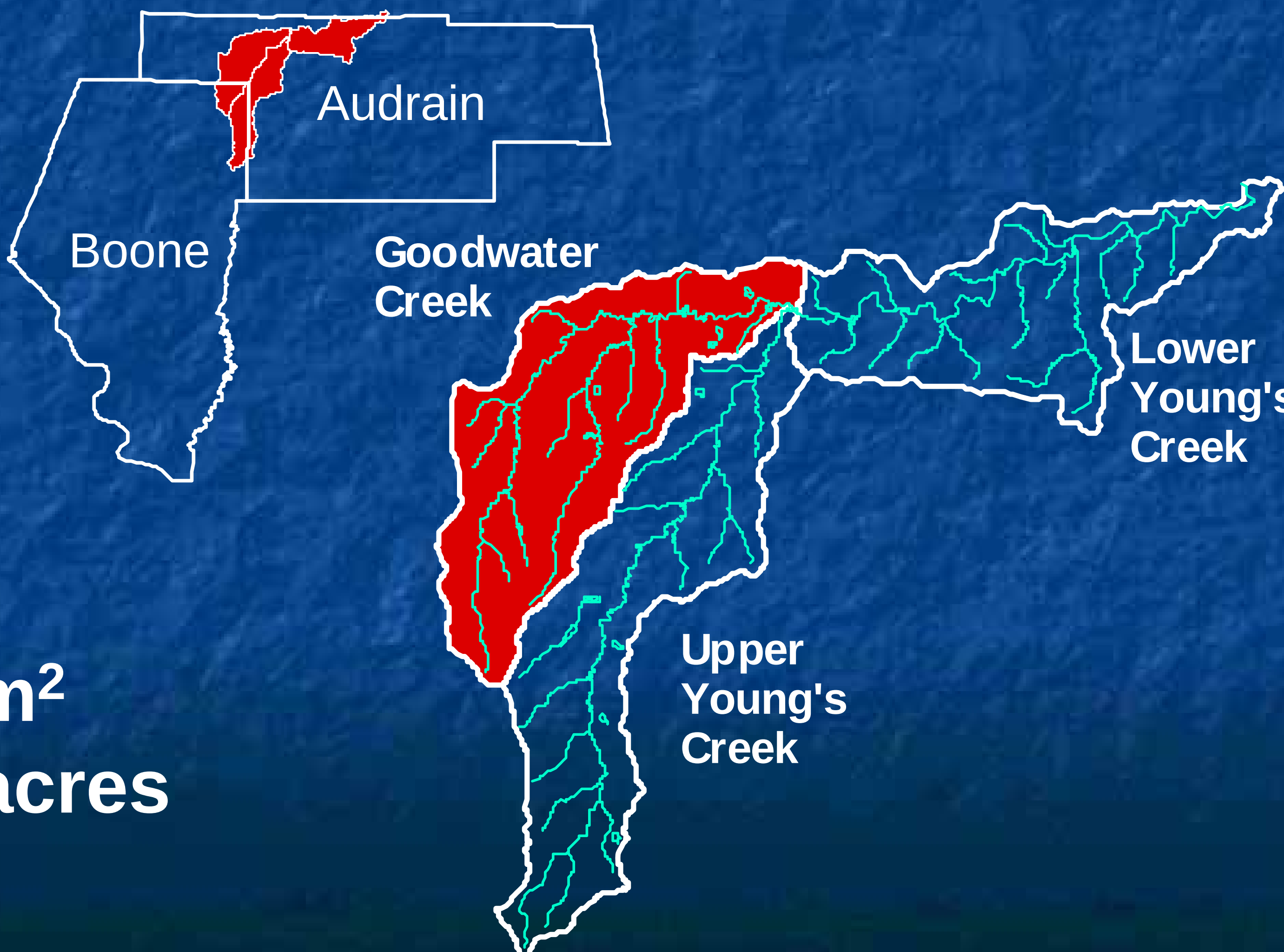
$$L_S = \frac{2 \cdot SW_{excess}}{\Phi_d \cdot D \cdot 1000} - L_{hill}$$

(2)

$$q = Ksat \cdot L_S \cdot 1000 + D \cdot Ksat \cdot \sin\alpha$$

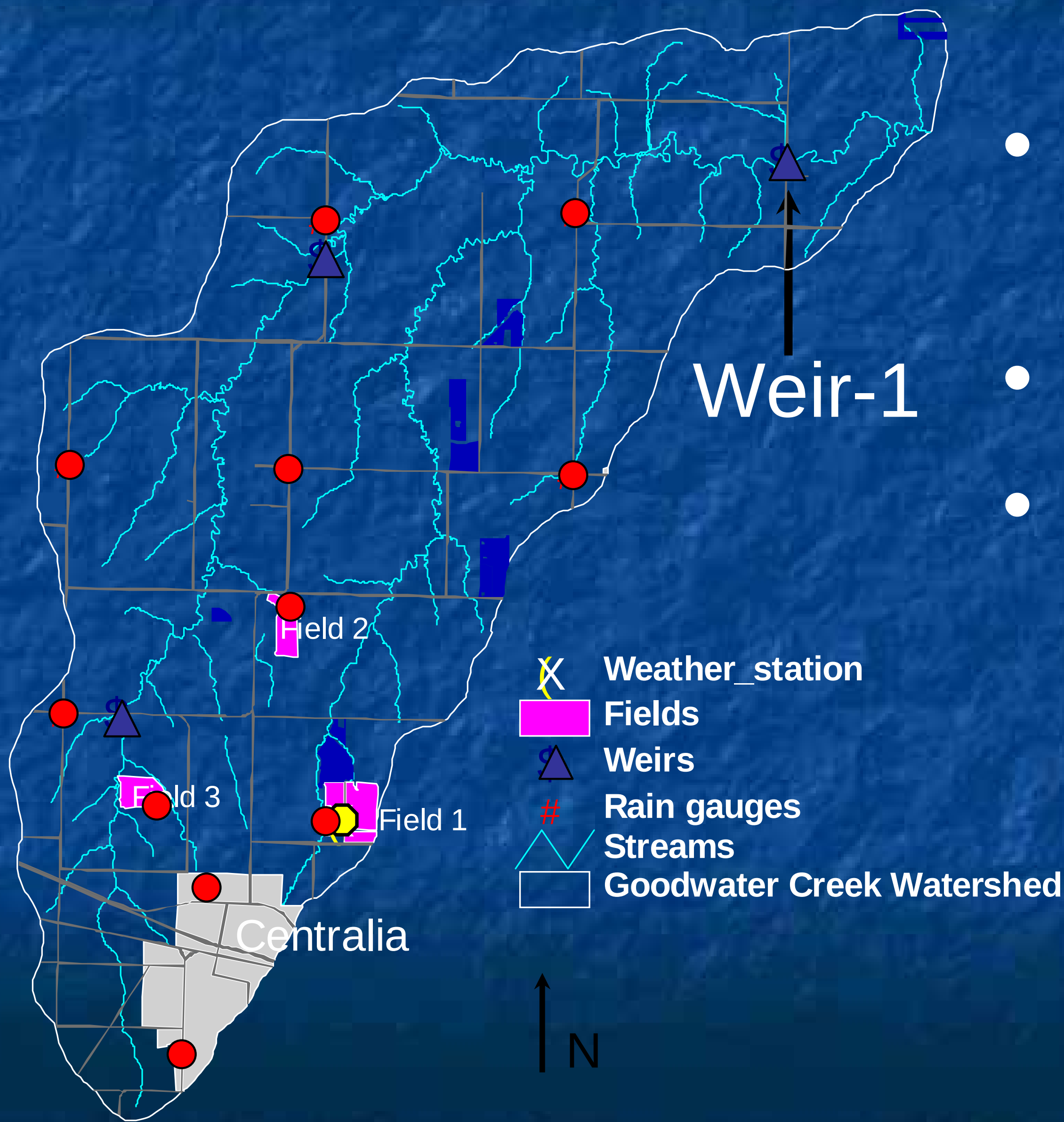
Goodwater Creek Experimental Watershed





72 km^2
16,000 acres

Goodwater Creek Watershed



- Claypan 15 to 45 cm below surface
- 0-3% slopes
- Land use
  - 74% Row Crops
  - 6% Woodland
  - 18% Grassland
  - 2% Urban

Results – SWAT2005

	Period	r^2	NSE	PBIAS SURQ	PBIAS GwQ	PBIAS TotQ
Weir 1	1993-1998	0.57	0.53	6%	-142%	-20%
Weir 1	1999-2004	0.39	0.36	20%	-168%	-11%
Weir 9	1993-1997	0.56	0.54	0%	-137%	-26%
Weir 11	1993-1998	0.60	0.57	17%	-241%	-22%

Results – SWAT2005-Revised

	Period	r^2	NSE	PBIAS SURQ	PBIAS GwQ	PBIAS TotQ
Weir 1	1993-1998	0.58	0.53	-4%	26%	0%
Weir 1	1999-2004	0.40	0.37	9%	2%	7%
Weir 9	1993-1997	0.58	0.58	-12%	19%	-7%
Weir 11	1993-1998	0.60	0.57	7%	-53%	-2%

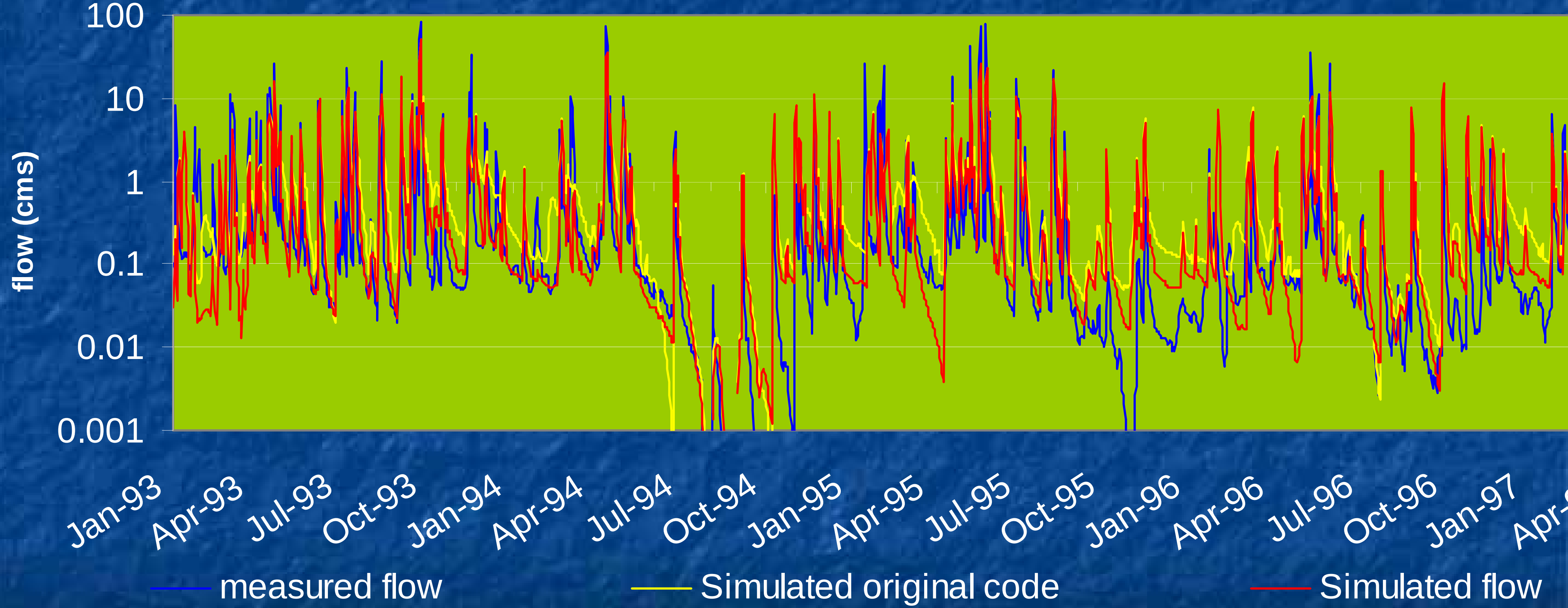
Results – SWAT2005-Revised

	Period	r^2	NSE	PBIAS SURQ	PBIAS GwQ	PBIAS TotQ
Weir 1	1993-1998	0.62	0.58	-7%	10%	-4%
Weir 1	1999-2006	0.53	0.49	-5%	-8%	-6%
Weir 9	1993-1997	0.65	0.63	-25%	-24%	-26%
Weir 11	1993-1998	0.67	0.60	17%	-51%	6%

Results – SWAT2005

	Period	r^2	NSE	PBIAS SURQ	PBIAS GwQ	PBIAS TotQ
Weir 1	1993-1998	0.61	0.56	9%	-188%	-26%
Weir 1	1999-2006	0.52	0.47	11%	-228%	-27%
Weir 9	1993-1997	0.62	0.60	-8%	-243%	-51%
Weir 11	1993-1998	0.66	0.58	26%	-239%	-13%

Weir 1 – 1993-1997



Summary

- Changes were incorporated to the model to simulate saturation conditions and lateral flow.
- These changes produced:
  - Improved simulation of groundwater flow
  - Improved simulation of total flow