Hydrological flow paths

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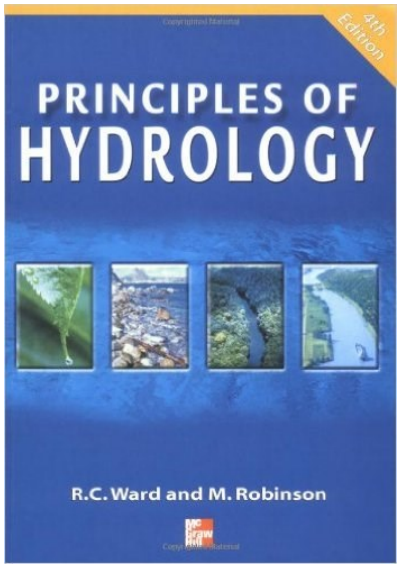
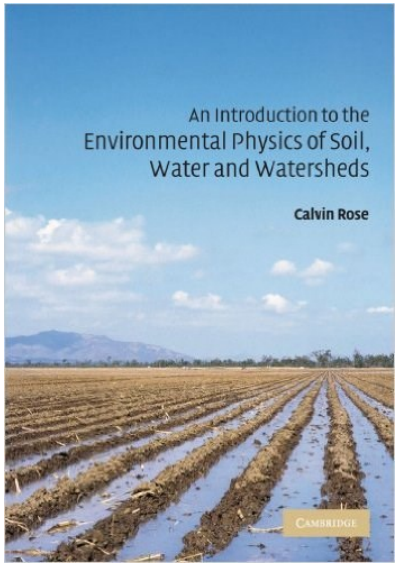
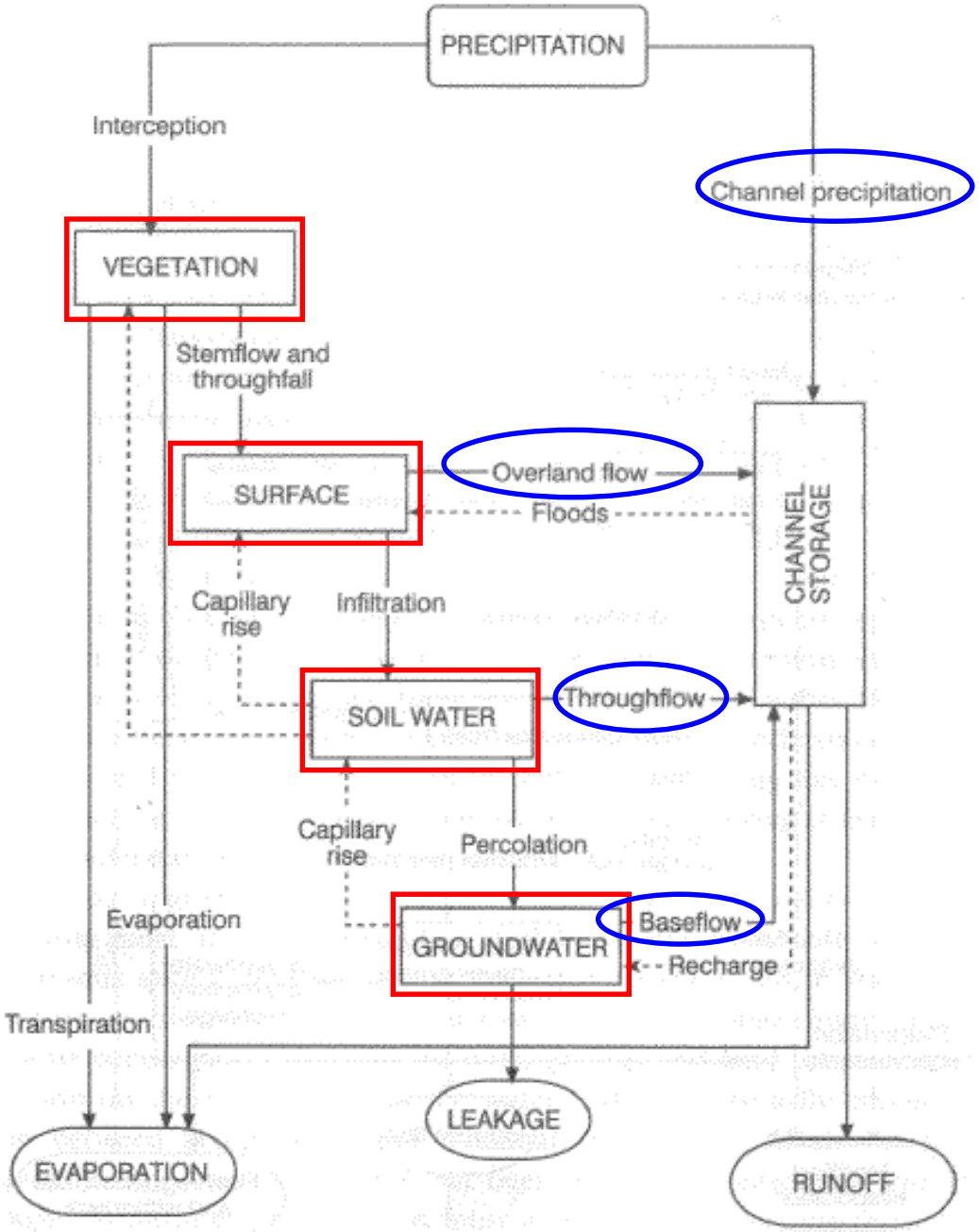
Soil, Water & Atmospheric Processes



Ward & Robinson – Runoff chapter

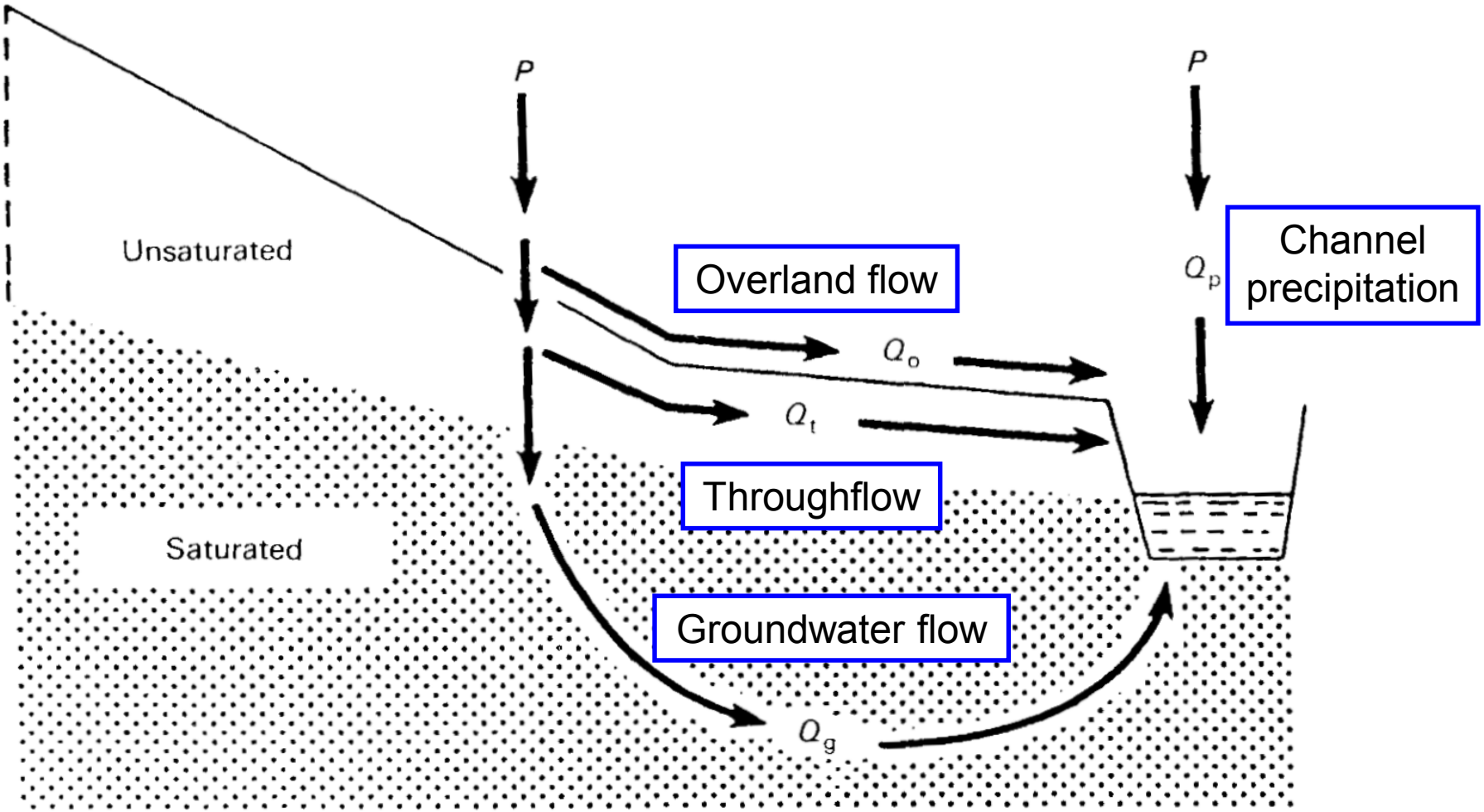


Rose – Chapter 7



(Ward & Robinson, 2000)

Runoff components



(Ward & Robinson, 1999)

Runoff components

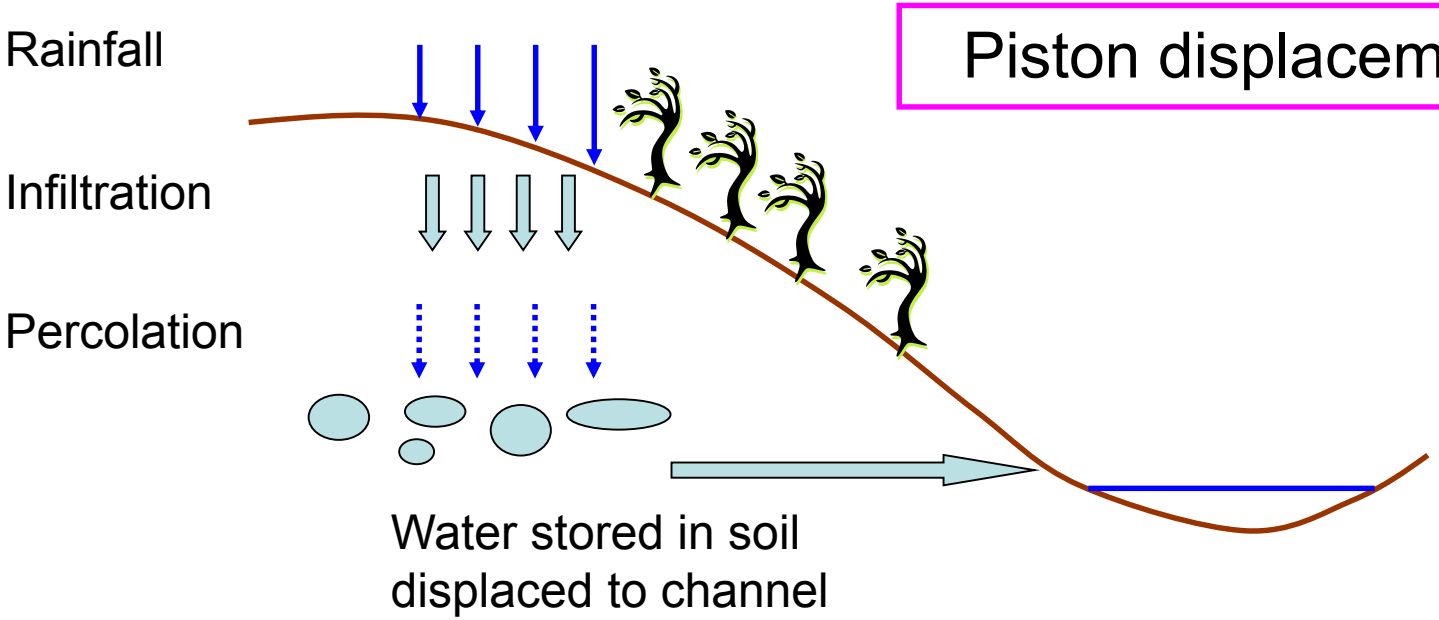
Channel precipitation

Groundwater flow

Overland flow

Throughflow

- Lateral hydraulic conductivity > vertical hydraulic conductivity
- Pipeflow



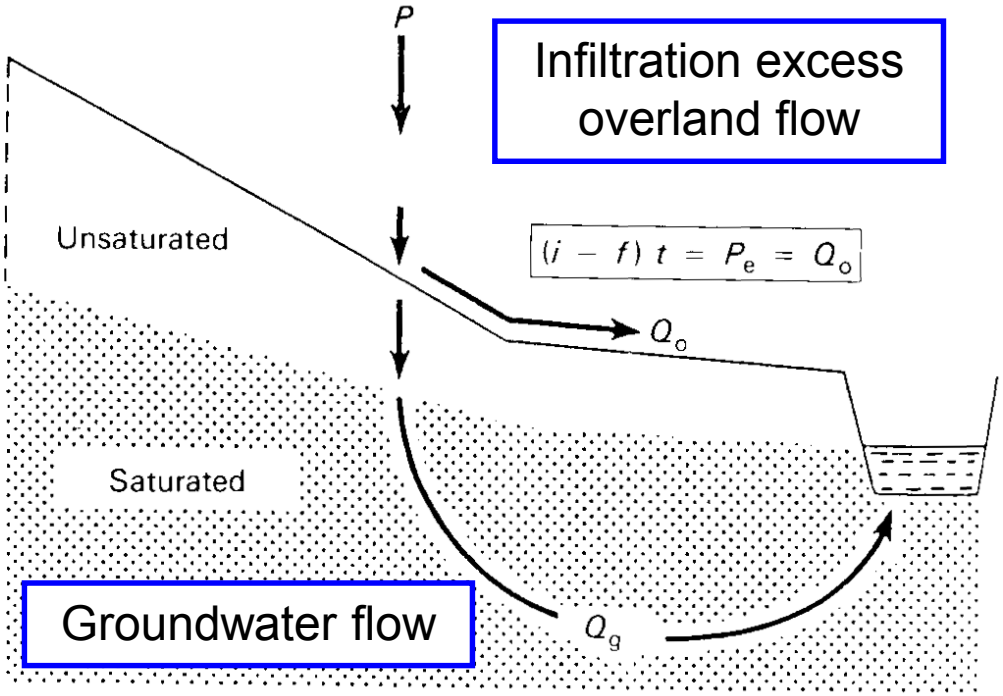
Flow medium	*Velocity (m hour^{1})*
Open channel	300-1000
Overland flow	50-500
Pipeflow	50-500
Matrix throughflow	0.005-0.2
Groundwater flow	
Sandstone	0.001-10
Shale	0.00000001-1.0
Jointed limestone	10-50

Contributions of different components vary in time and space

Horton model of streamflow generation

- Proposed in 1933 by Robert E. Horton
- Overland flow main source of stormflow
- Infiltration rate declined rapidly during rainfall events
- Most applicable to semi-arid, arid & urban catchments

http://abouthydrology.blogspot.co.uk

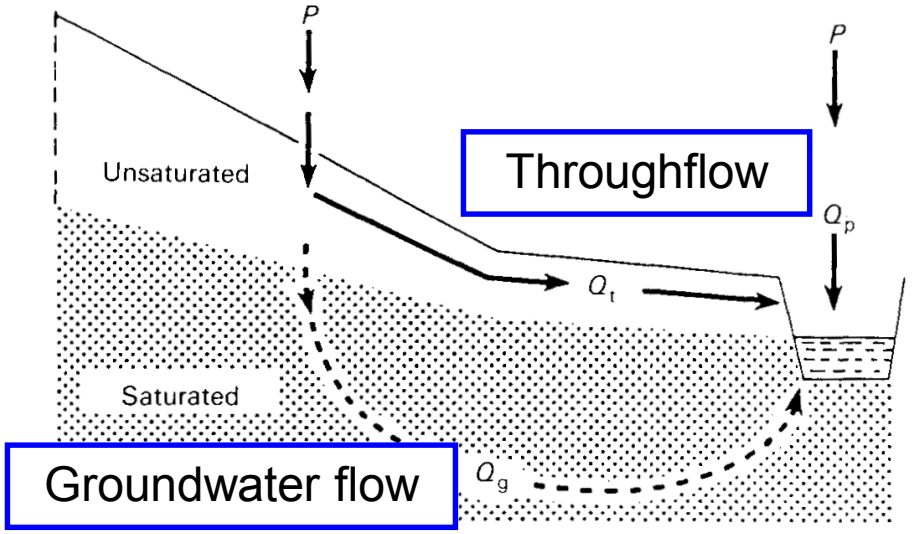


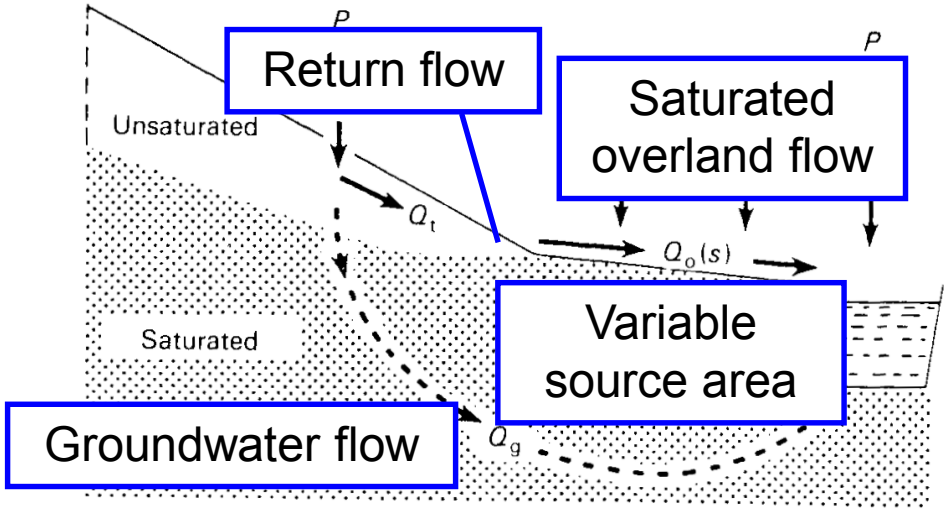
(Ward & Robinson, 1999)

Hewlett model of streamflow generation

www.history-of-hydrology.net

- BUT Hortonian overland flow not observed in humid forested catchments in E. USA
- => new model, emphasising role of throughflow
  - Variable source areas
  - Saturated overland flow

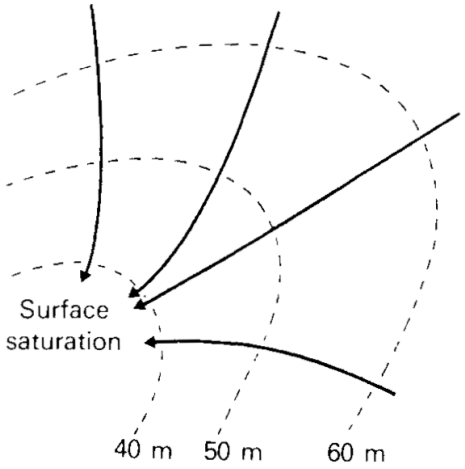




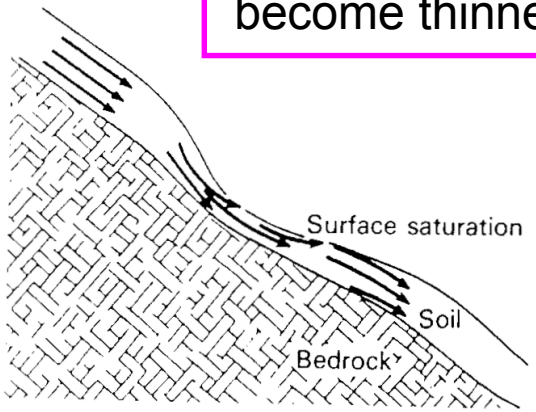
(Ward & Robinson, 1999)

Locations of variable source areas

Hillslope hollows



Where soils become thinner



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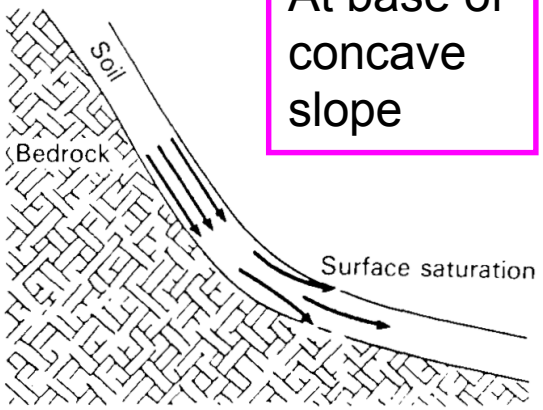
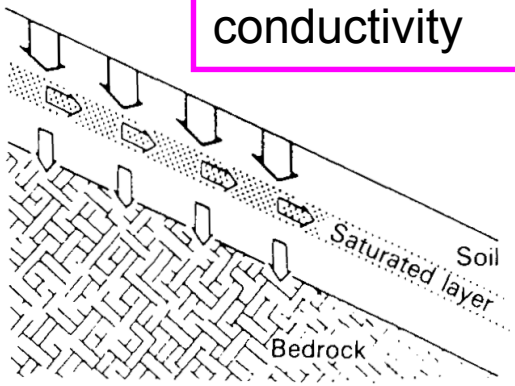
At base of concave slope

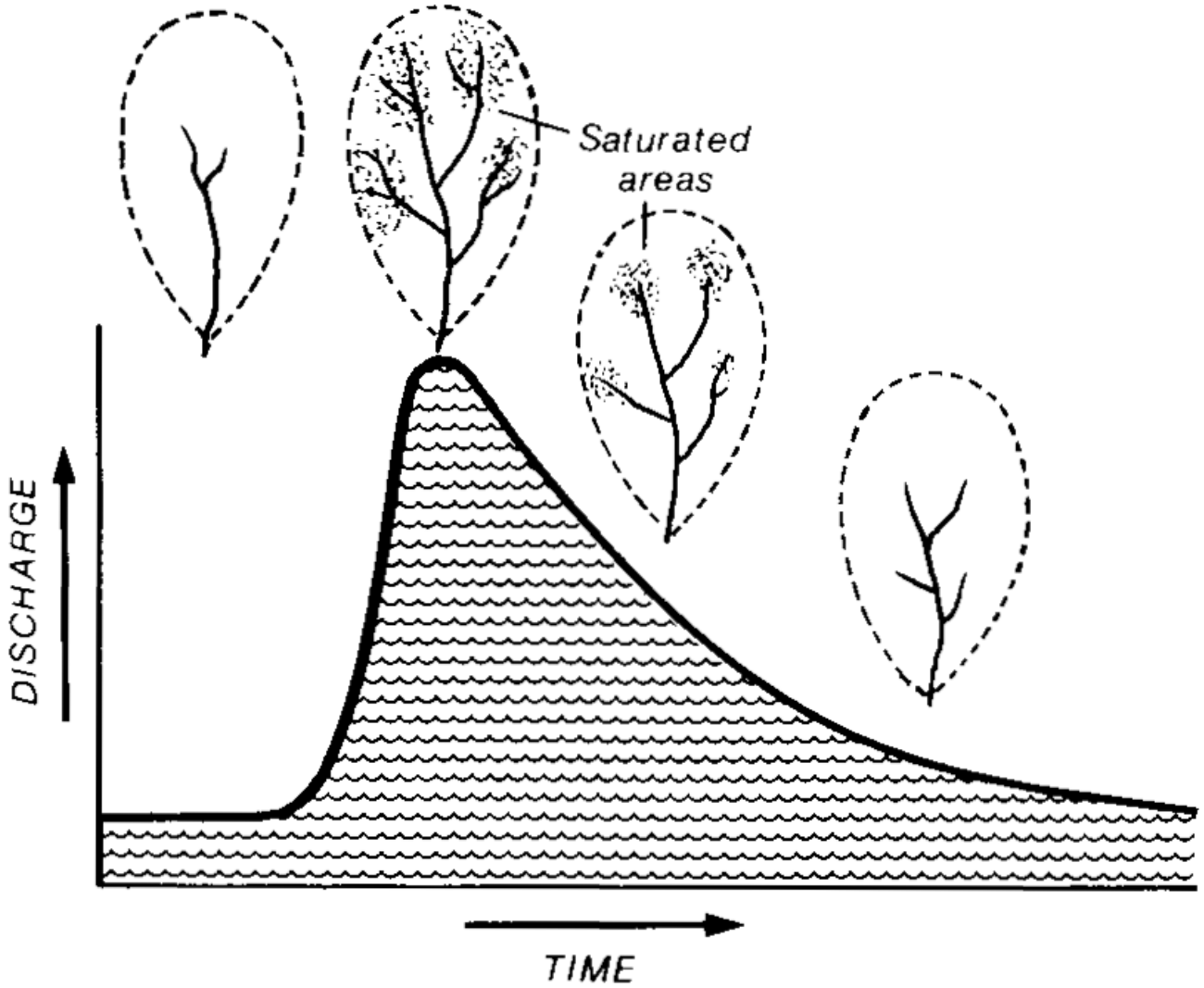


Soil layer with low hydraulic conductivity



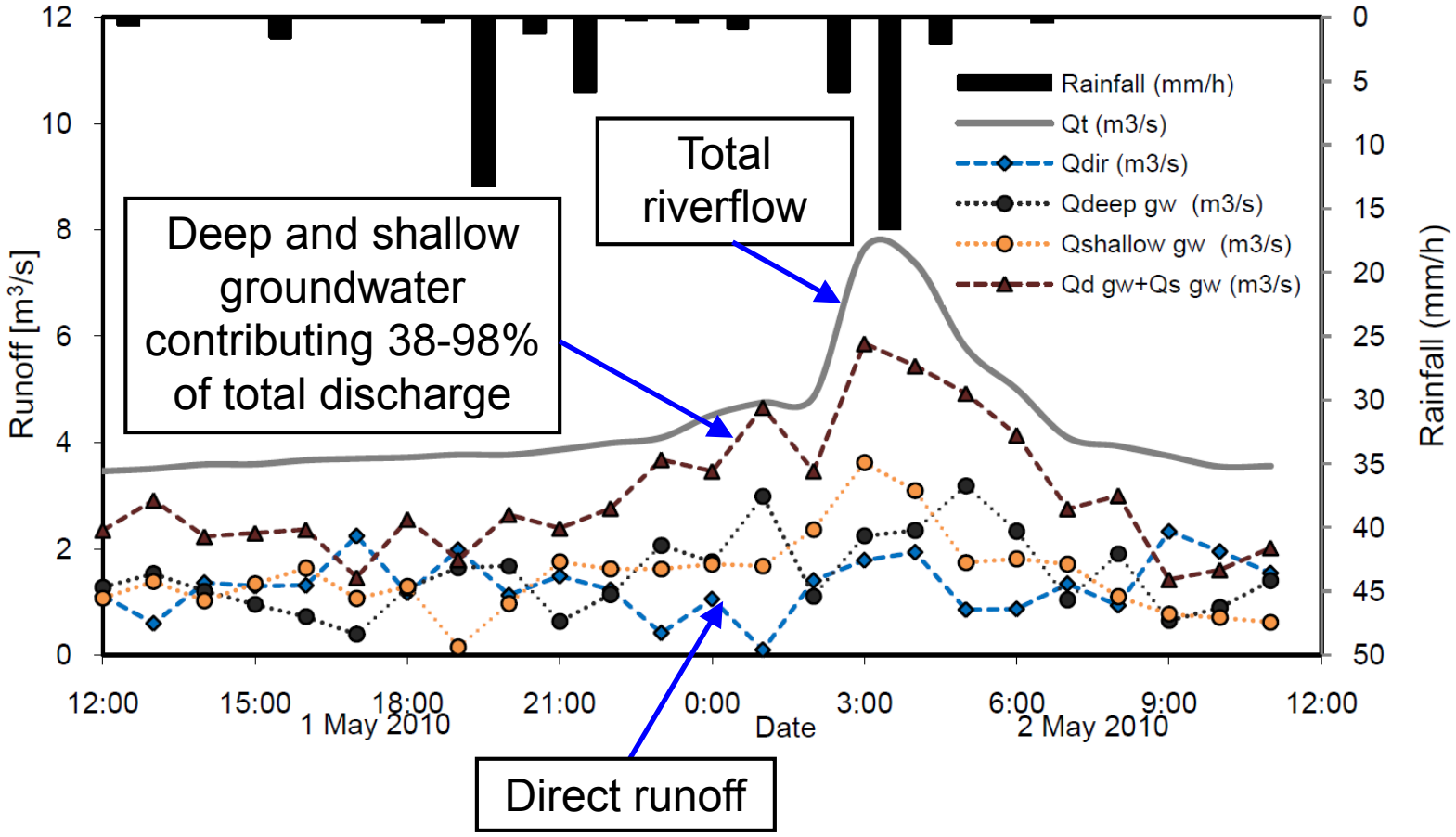
(Ward & Robinson, 1999)

Variable source areas change over time and space



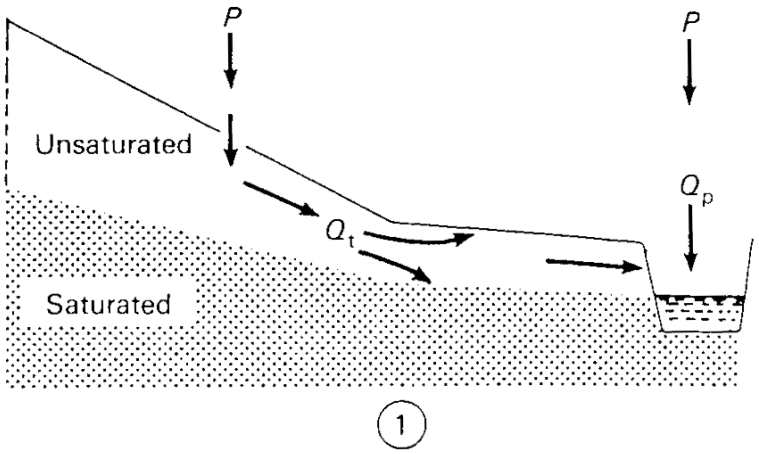
Tracer studies (natural chemical and stable isotopes) => "groundwater" can contribute 60-80% of stormflow

Hydrograph separation using dissolved silica and deuterium (^2H) as tracers

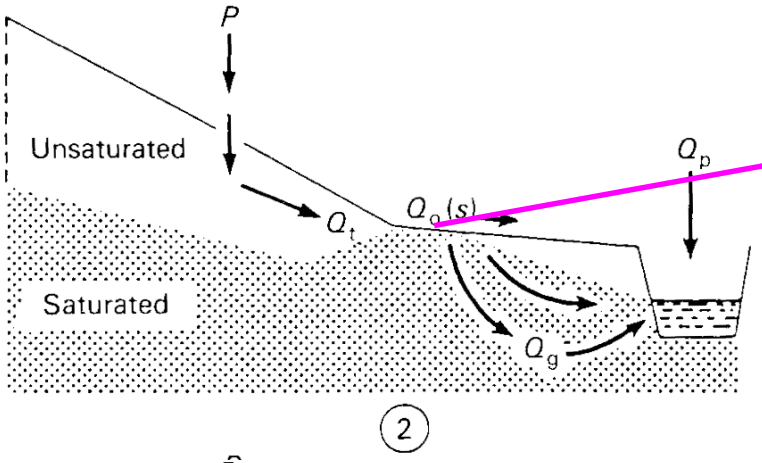


Munyaneza et al. (2012) *Hydrology and Earth System Sciences* **16**, 1991-2004

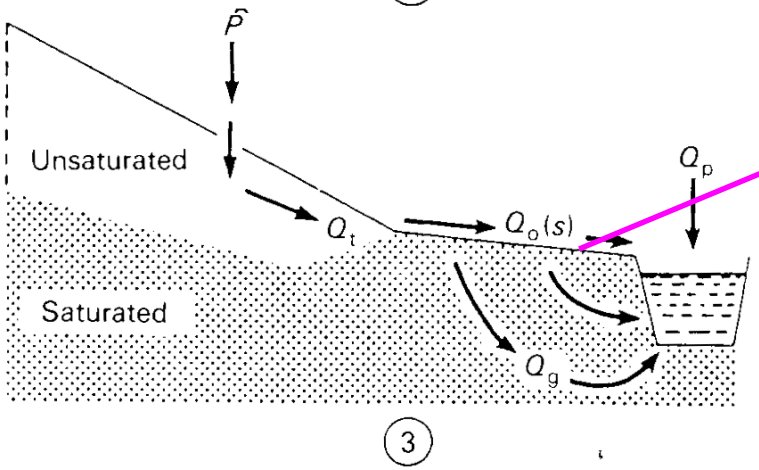
Groundwater ridging



Rapid conversion of a shallow capillary fringe from near-saturated to saturated conditions during a rainfall event



Occurs as result of intense rainfall at ground surface causing: 1) relief of capillary tension and/or 2) rapid addition of potential energy



Steep hydraulic gradient between ridge and river water => rapid groundwater flow

(Ward & Robinson, 1999)

Which do you think is the dominant runoff process in these situations?

- Hot arid environment?
- Princes Street?
- Temperate forest?
- Conifer plantation with drainage ditches?
- Field with high density of livestock?
- Peat moorland in wet winter?
- Peat moorland after a dry summer?
- Catchment with large area of wetland?

Summary of runoff processes and their controls