
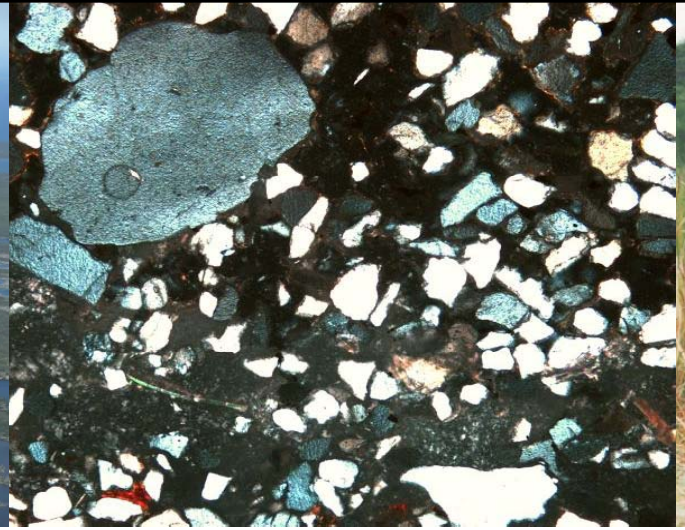


DEC TEC Course
4th of November 2009
Surface Water Groundwater Interactions

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Department of Environment and Conservation

Outline

- Streams and Rivers
  - Baseflow – gaining stream
  - Stream loss – losing stream
  - Disconnected stream
  - Bank storage and effect of stream stage variation (flooding)
- Lakes and ephemeral water bodies
  - Recharge
  - Discharge
  - Through flow
  - Variants of the above in time and space
  - Effect of lake sediments
- Oceans (brief intro)
  - Intertidal discharge
  - Offshore discharge
- Groundwater Discharge Evidence

Interactions With Streams/Rivers

- One of the best understood SW – GW interactions pertains to streams
- Baseflow of a stream is the component of the total flow that is due to groundwater
- Baseflow often maintains streamflow when the surface of the landscape is completely dry

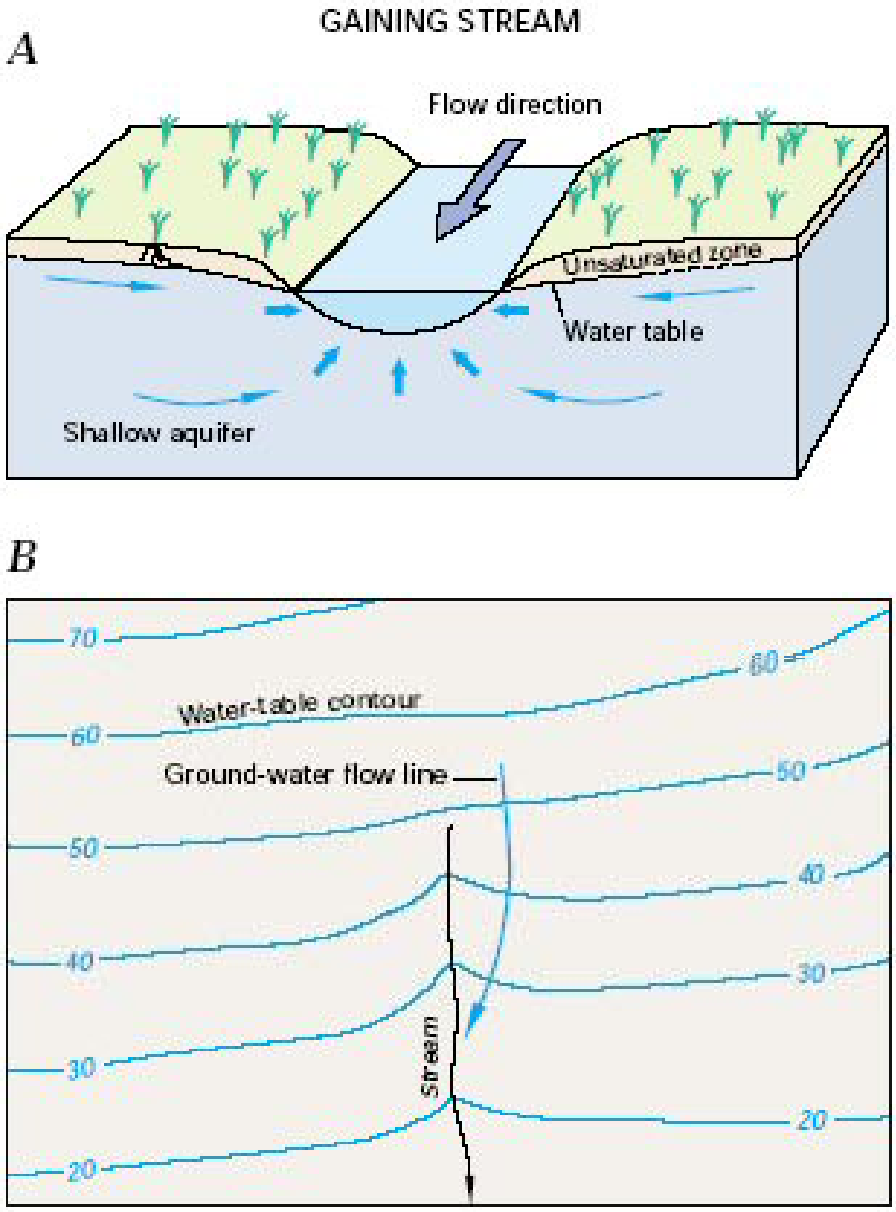


Figure 8. *Gaining streams receive water from the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the upstream direction where they cross the stream (B).*

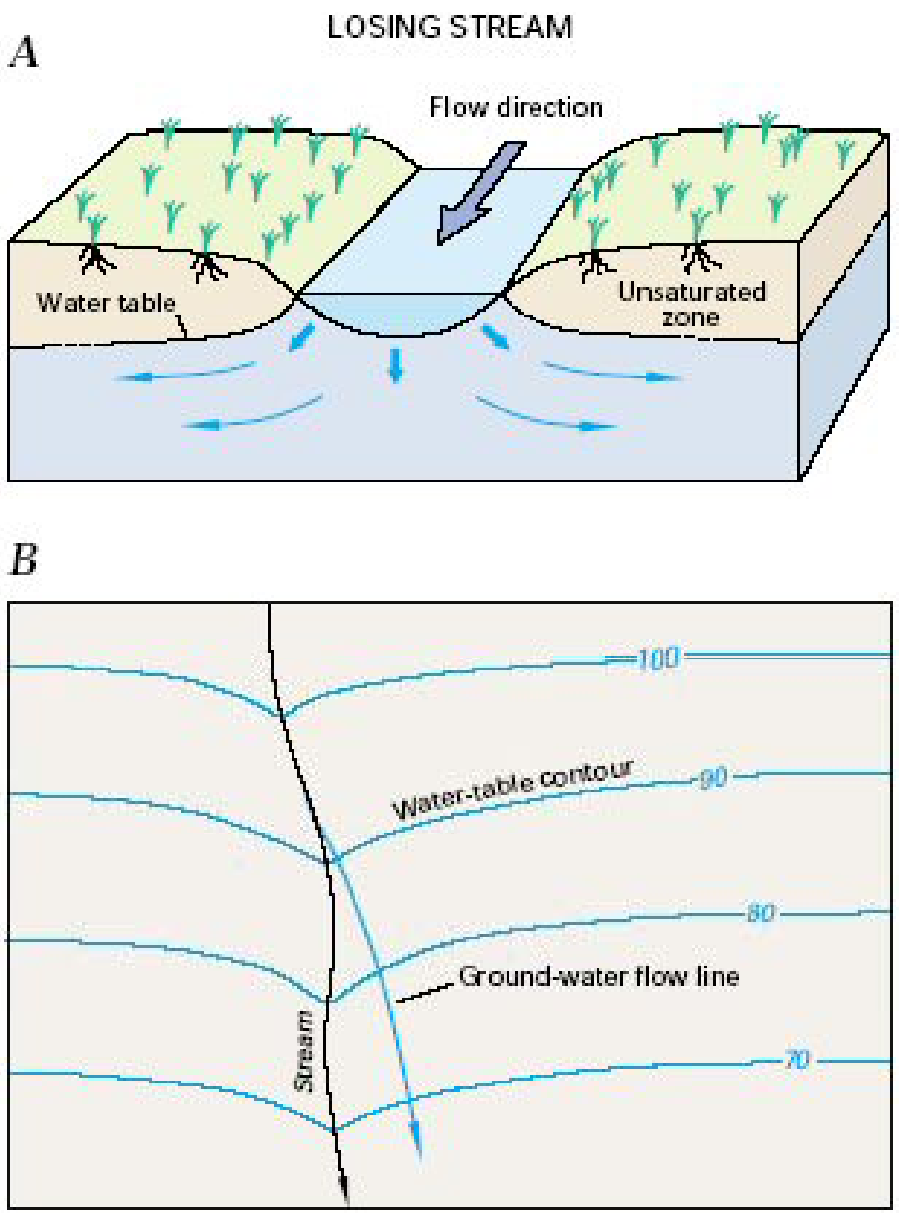


Figure 9. *Losing streams lose water to the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the downstream direction where they cross the stream (B).*

USGS Circular 1139, 1998

Disconnected Streams and Bank Storage

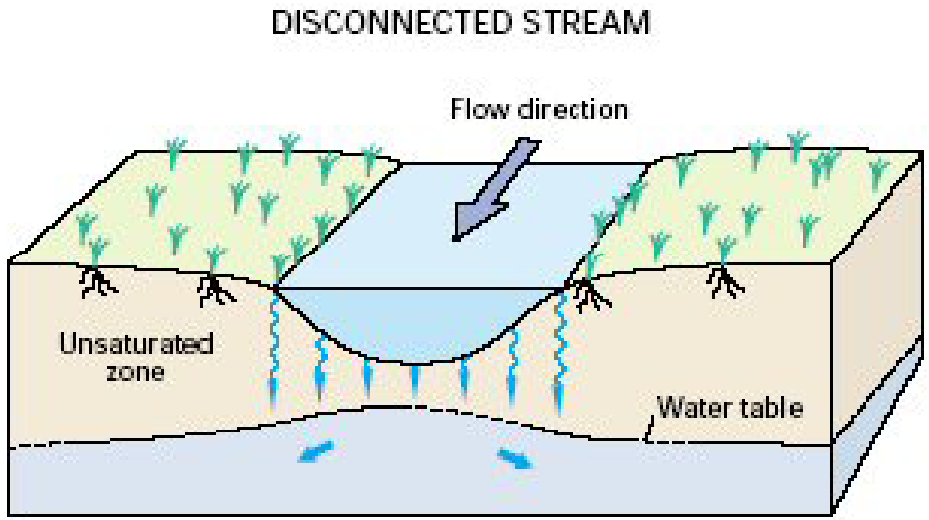


Figure 10. Disconnected streams are separated from the ground-water system by an unsaturated zone.

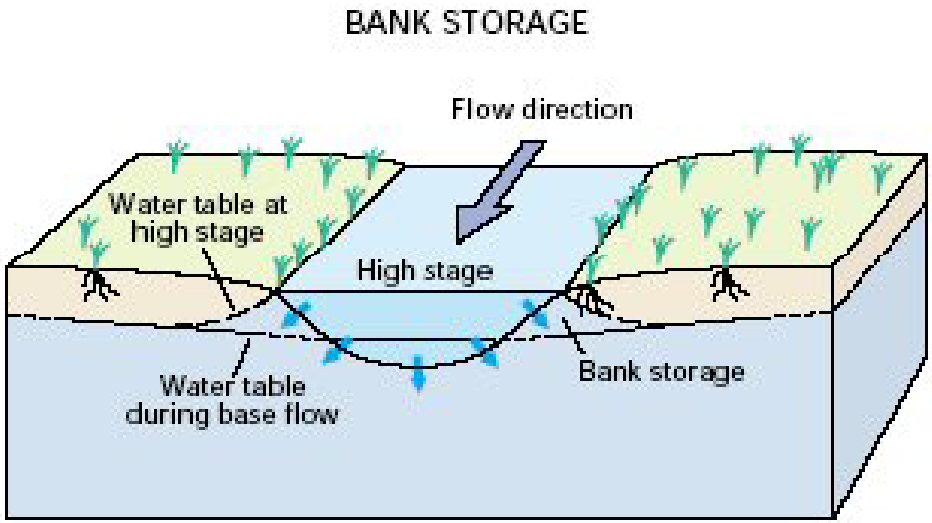
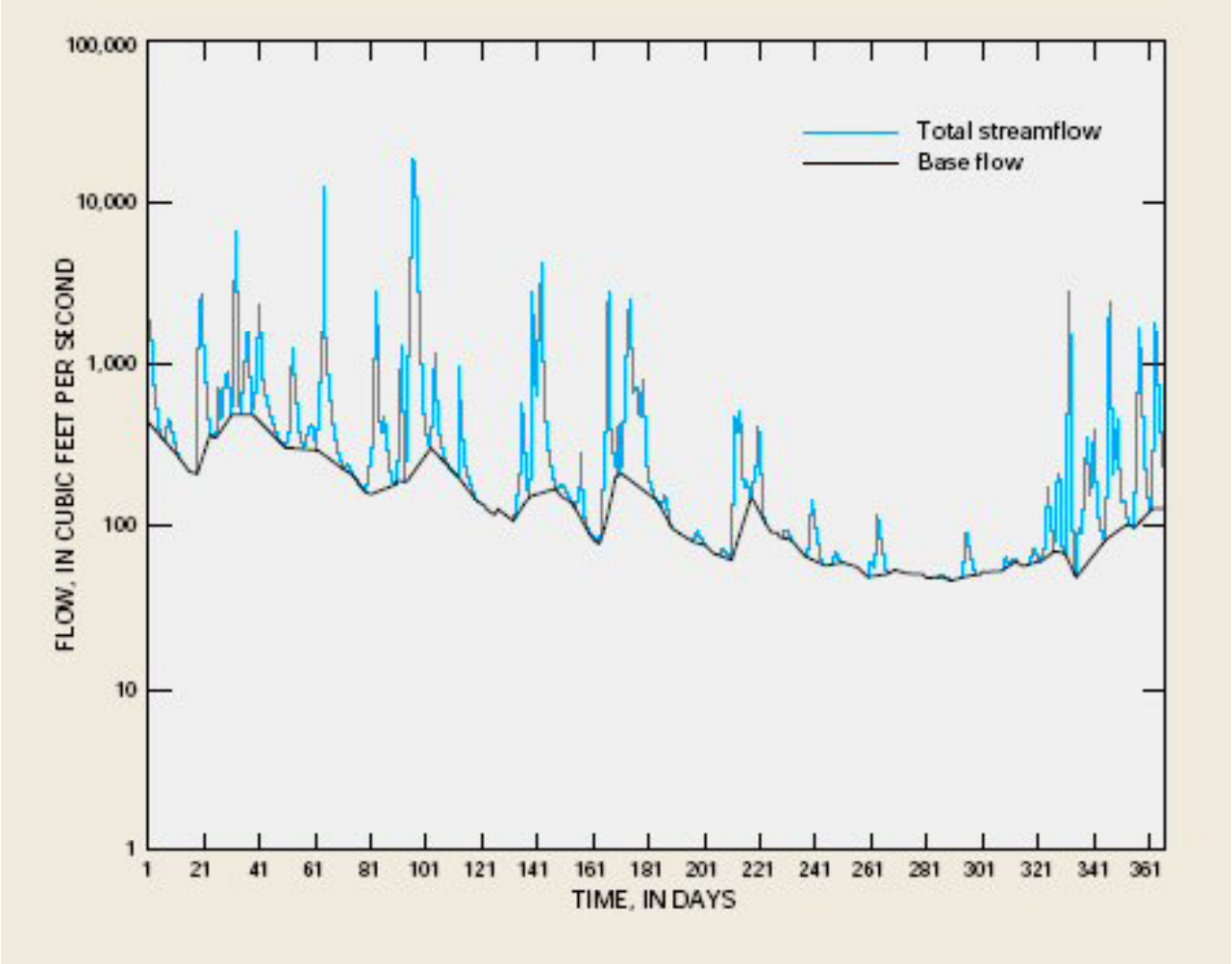


Figure 11. If stream levels rise higher than adjacent ground-water levels, stream water moves into the streambanks as bank storage.

USGS Circular 1139, 1998

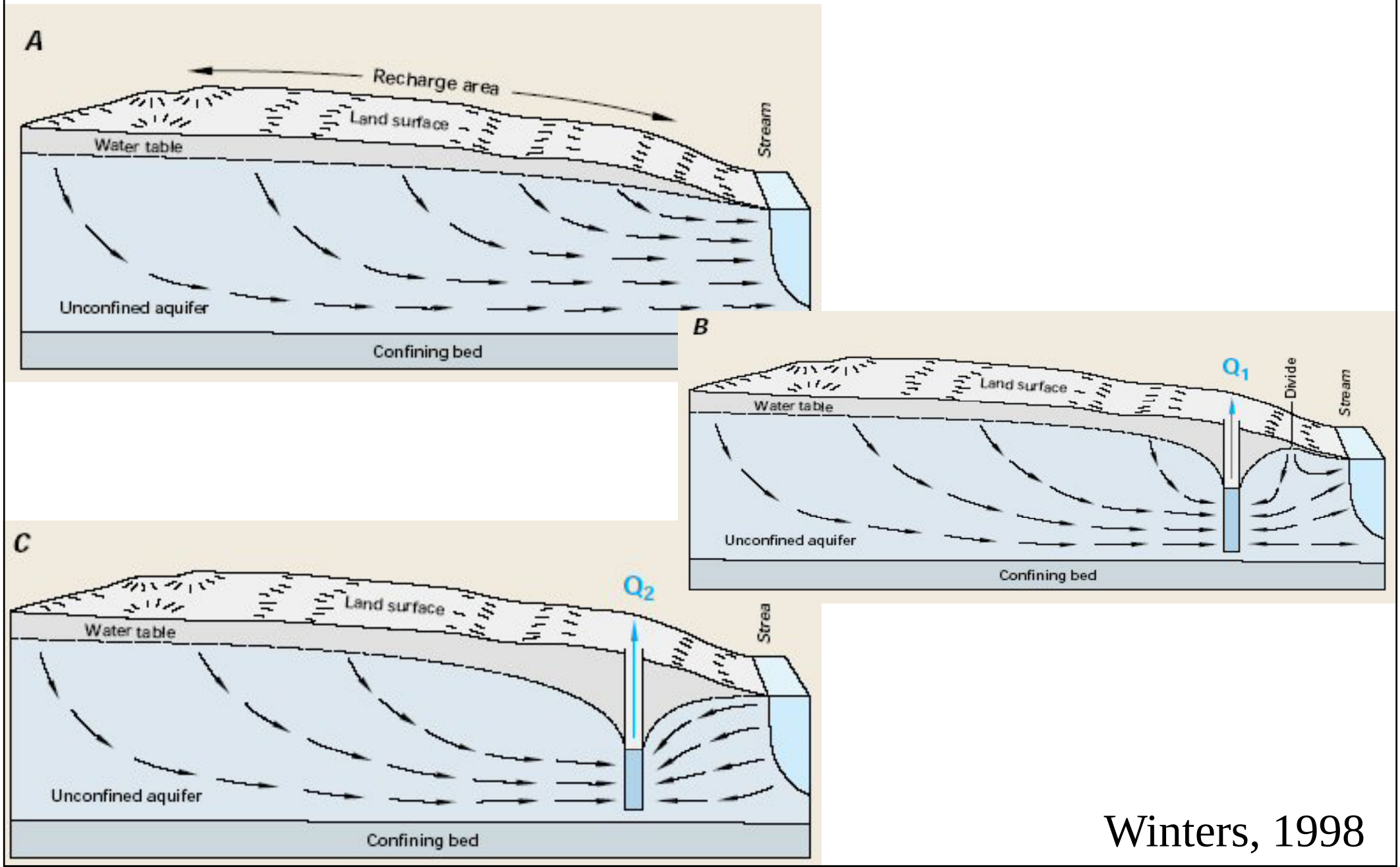
River Streamflow and Baseflow

- Baseflow remains relatively constant
- Total flow is an expression of surface runoff
- Will usually correlate to rainfall events, may lag due to catchment dynamics



USGS Circular 1139, 1998

Effects of GW Withdrawls



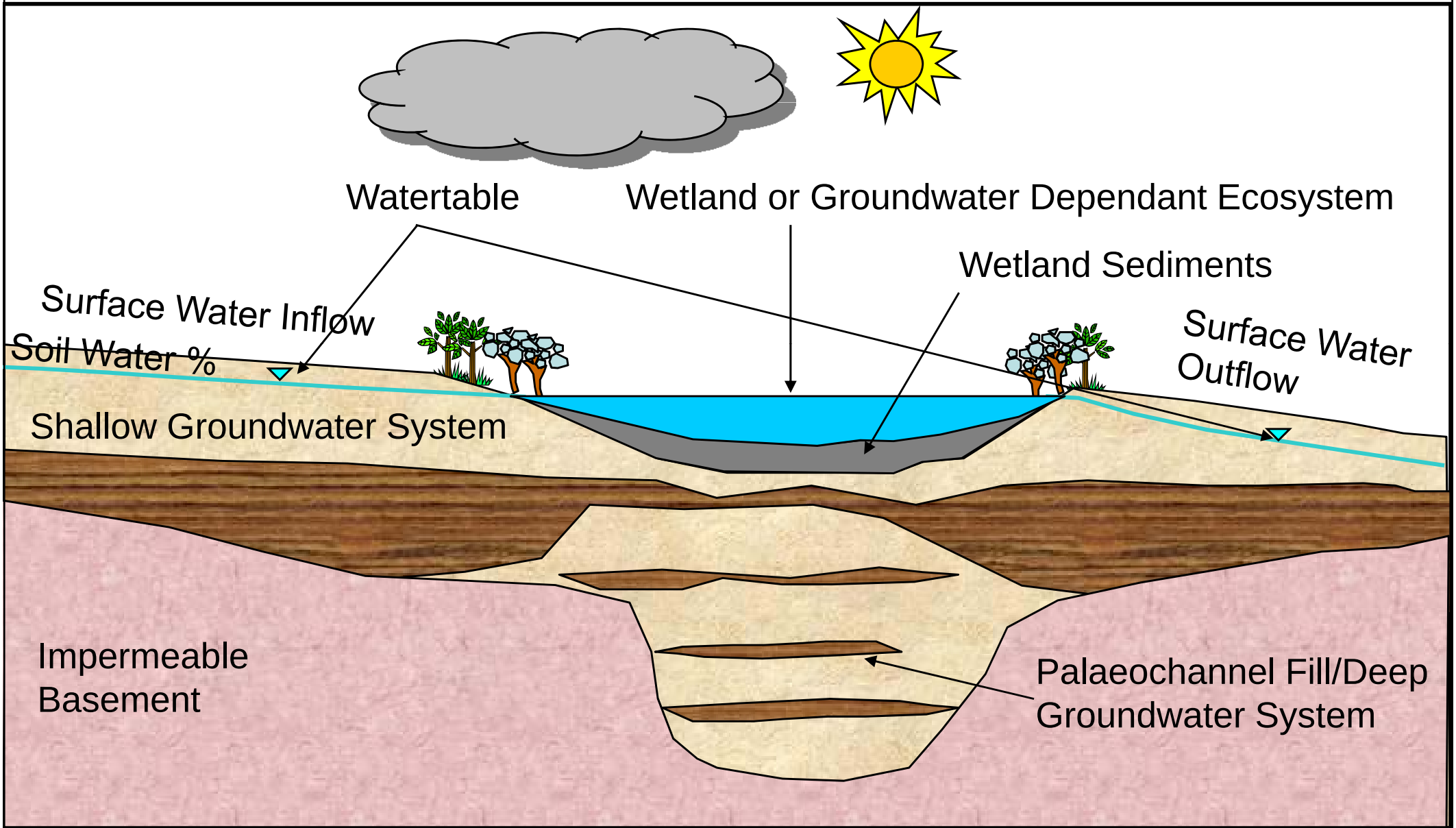
Winters, 1998

Lakes and Ephemeral Water Bodies

- Lakes, ephemeral water bodies and wetlands are very important hydrogeologically
- Sites of large amounts of groundwater surface water interaction including both recharge and discharge
- Often they are essential “outcroppings” of the water table although low K sediments often present in the base of wetlands can often attenuate the connection between the surface and groundwater
- They often provide substantial ecosystem services for humans (water supply, flood mitigation, recreation etc) and are crucial habitat for flora and fauna

Key areas of understanding for definition of wetland function

Description of the following figures.

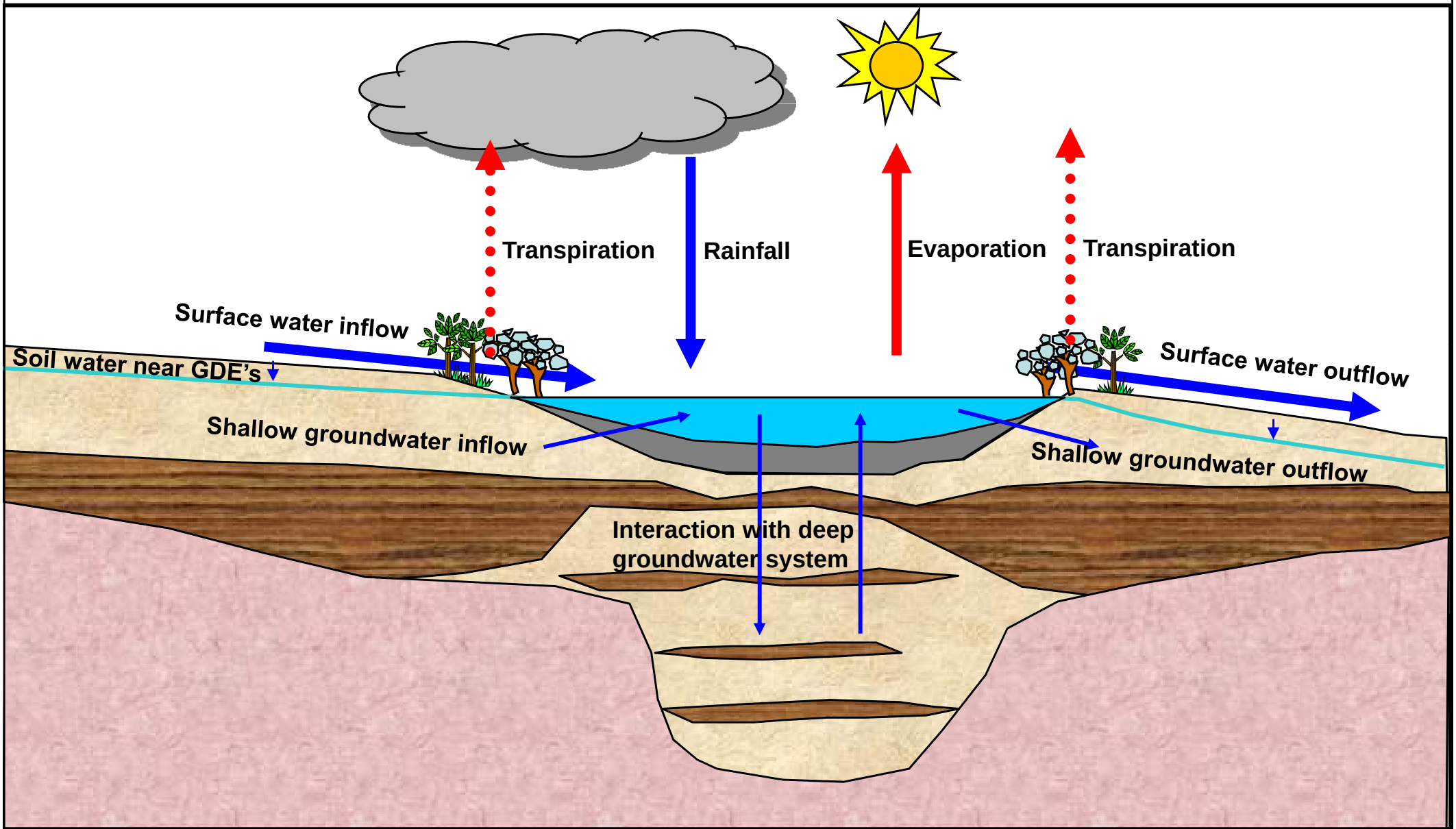


For all of the pathways shown below we need to understand;

A – the movement of water.

B – the movement of salt with that water.

C – the movement and interaction of other water constituents (N, P, SO_4, Cl acidity/alkalinity etc).



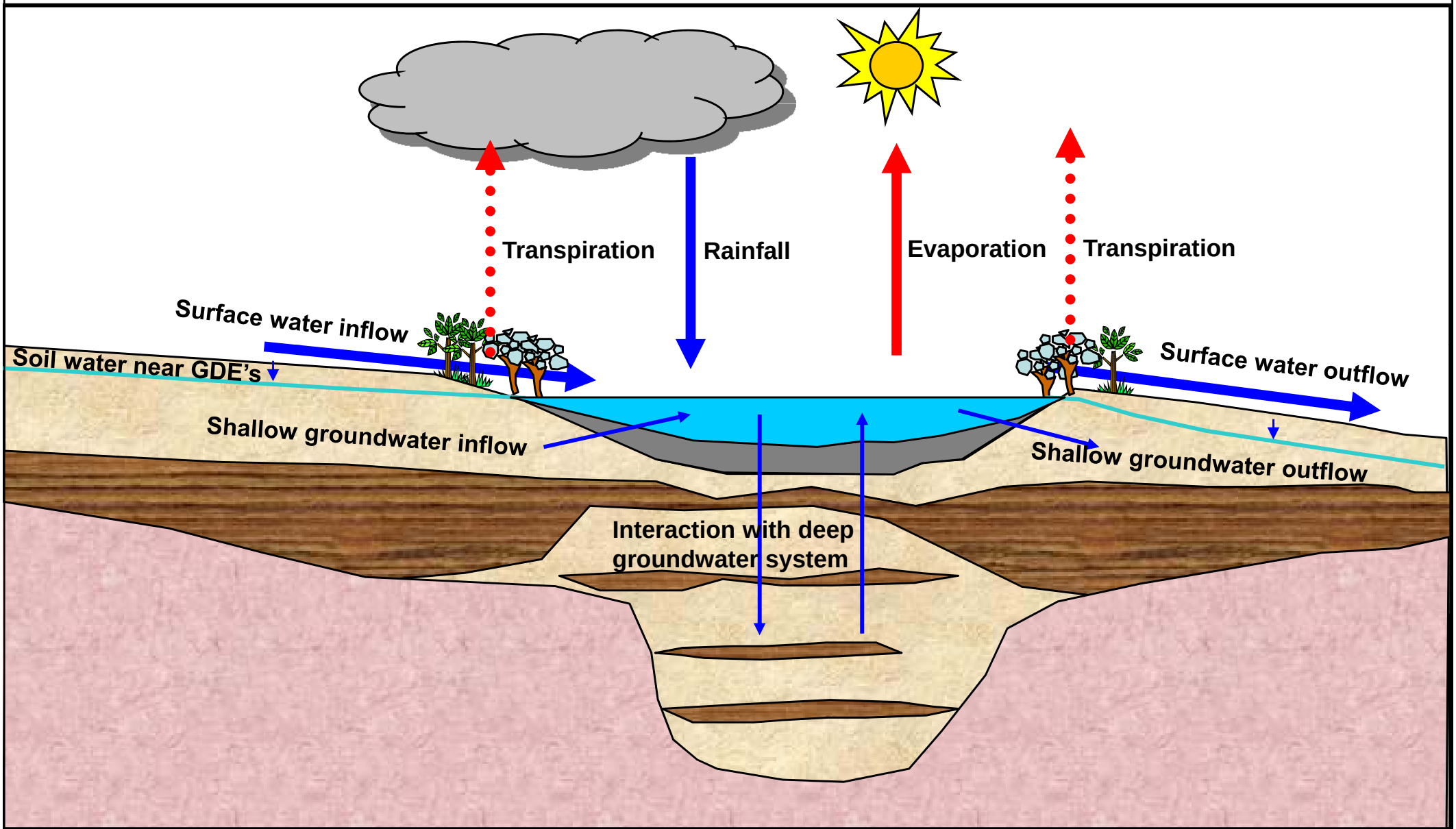
But also how the movement of that water will react with sediments including;

A – precipitation and dissolution.

B – erosion and deposition.

C –oxidation and reduction.

D – adsorption, desorption and eutrophication.



Recharge and Discharge Mechanisms

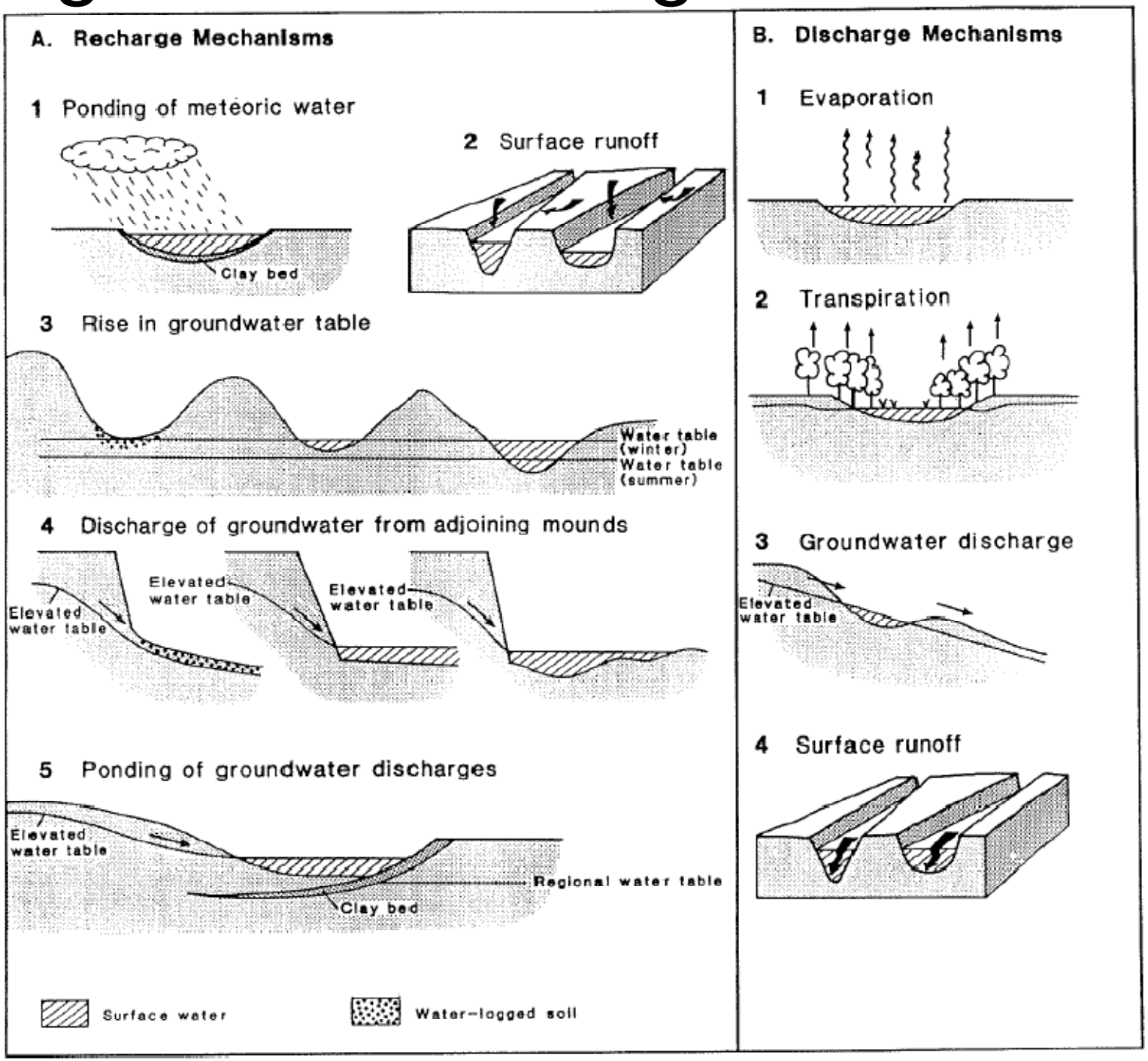
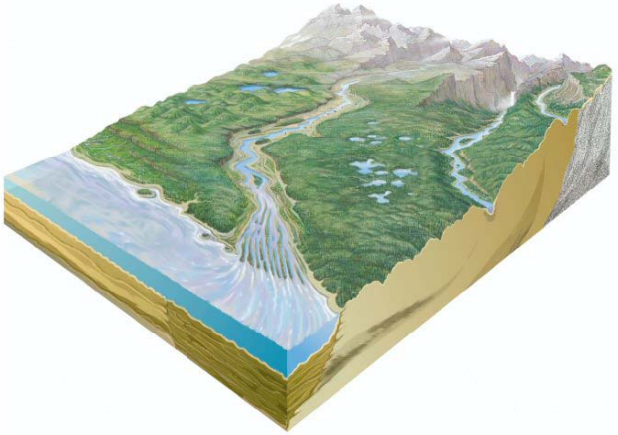
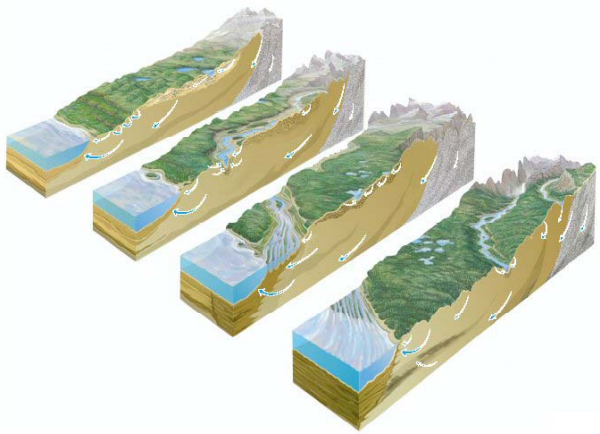


Figure 4.2 Potential recharge and discharge patterns of wetlands

Adapted from, Wetlands of the Swan Coastal Plain, (1994)





Different Types of Wetland And Interactions Occur in Different Parts of the Landscape

Adapted from, Wetlands of the Swan Coastal Plain, (1994)

Classification of wetland types by Semeniuk (1987).

	Landform		
Water Longevity	Basin	Channel	Flat
Permanent Inundation	Lake	River	–
Seasonal Inundation	Sumpland	Creek	Floodplain
Seasonal Waterlogging	Dampland	–	Palusplain

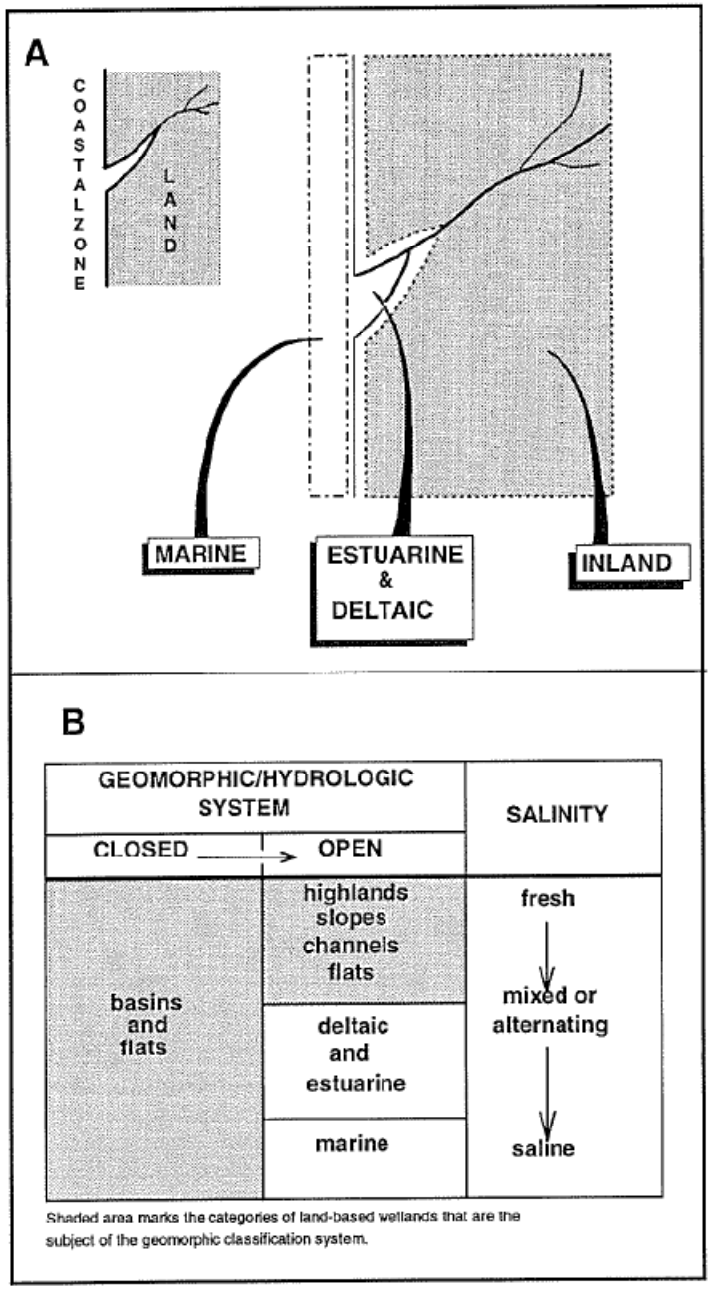


Figure 2.1 Wetland systems included in the geomorphic classification system.

Hydroperiod Verses Type of Wetland

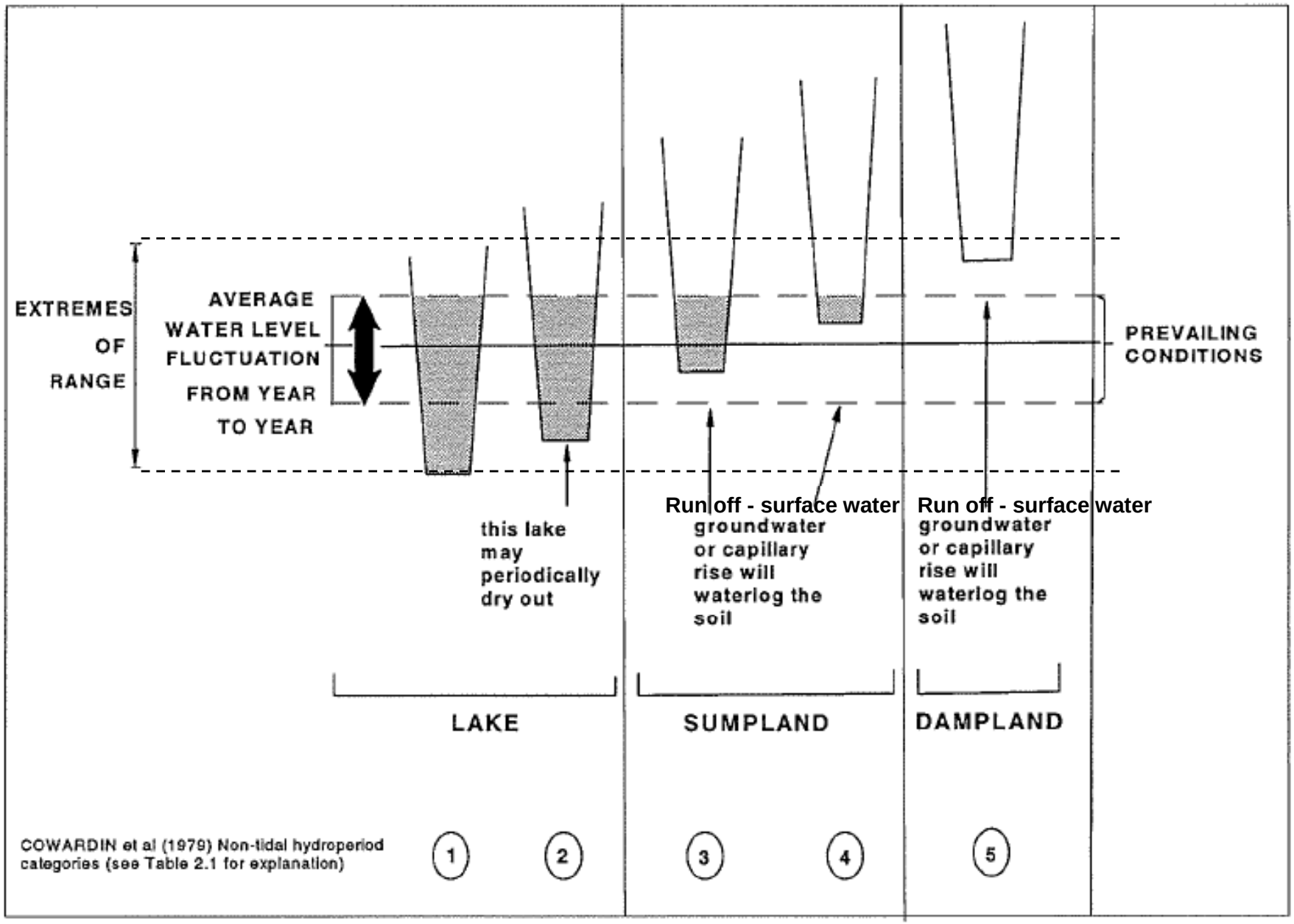


Figure 2.5 Non-tidal hydro-period categories.

Adapted from, Wetlands of the Swan Coastal Plain, (1994)

Consanguineous Wetlands

A series of proximal wetlands may all be related to the same hydrogeological system and hence function/impacts are inter-related.

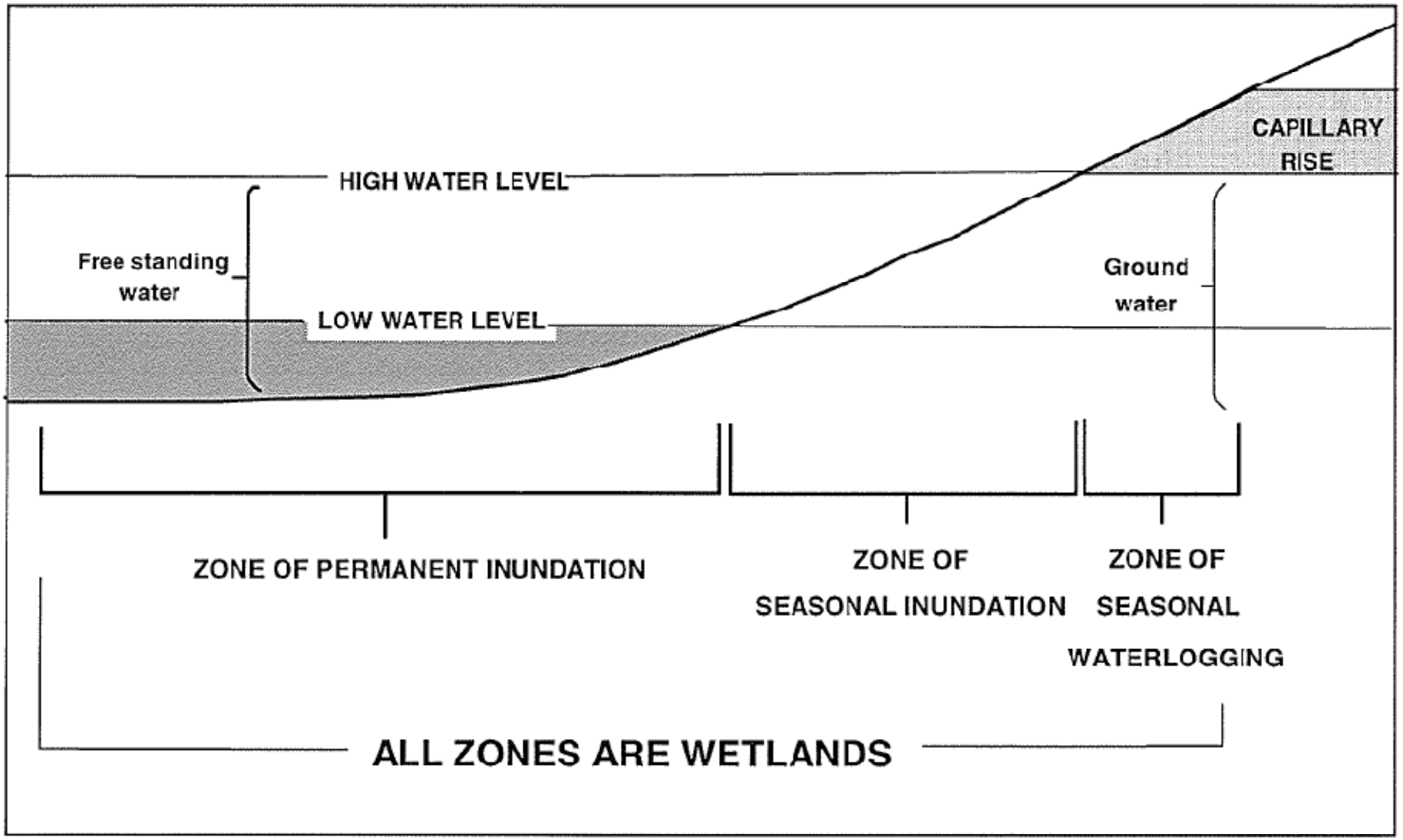
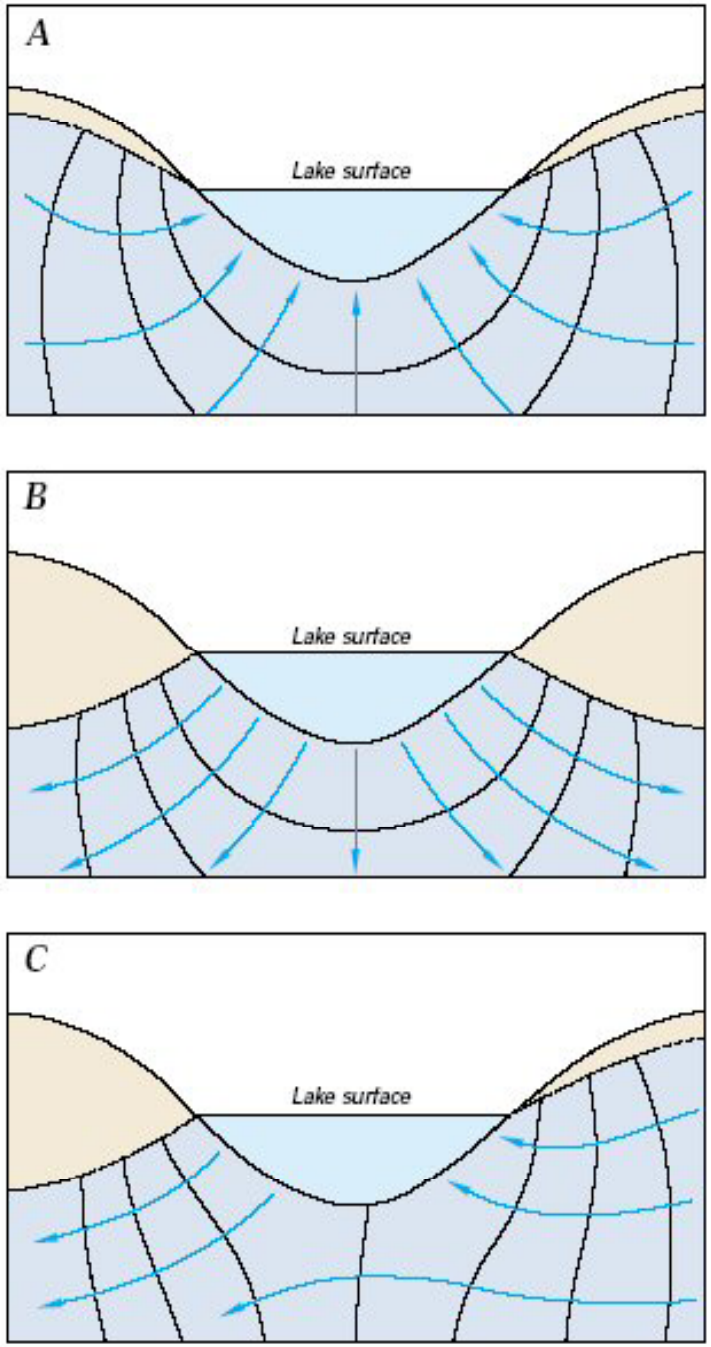


Figure 2.2 Cross-sectional view of zones of a wetland.

Adapted from, Wetlands of the Swan Coastal Plain, (1994)

Interactions With Surface Bodies

- Groundwater interacts with surface water bodies in three primary ways:
  - **A) Discharge body** – groundwater levels above lake levels
  - **B) Recharge body** - groundwater levels below lake levels
  - **C) Flow-thru body** - groundwater levels above lake levels on one side and lower on the other
- Note these are end members and some variation in a particular wetland may be possible within an annual cycle under natural conditions.
- Land use and water balance changes in the surface water or groundwater catchments may cause changes to the way wetlands interact with the groundwater environment



USGS Circular 1139, 1998

Interactions With Surface Bodies

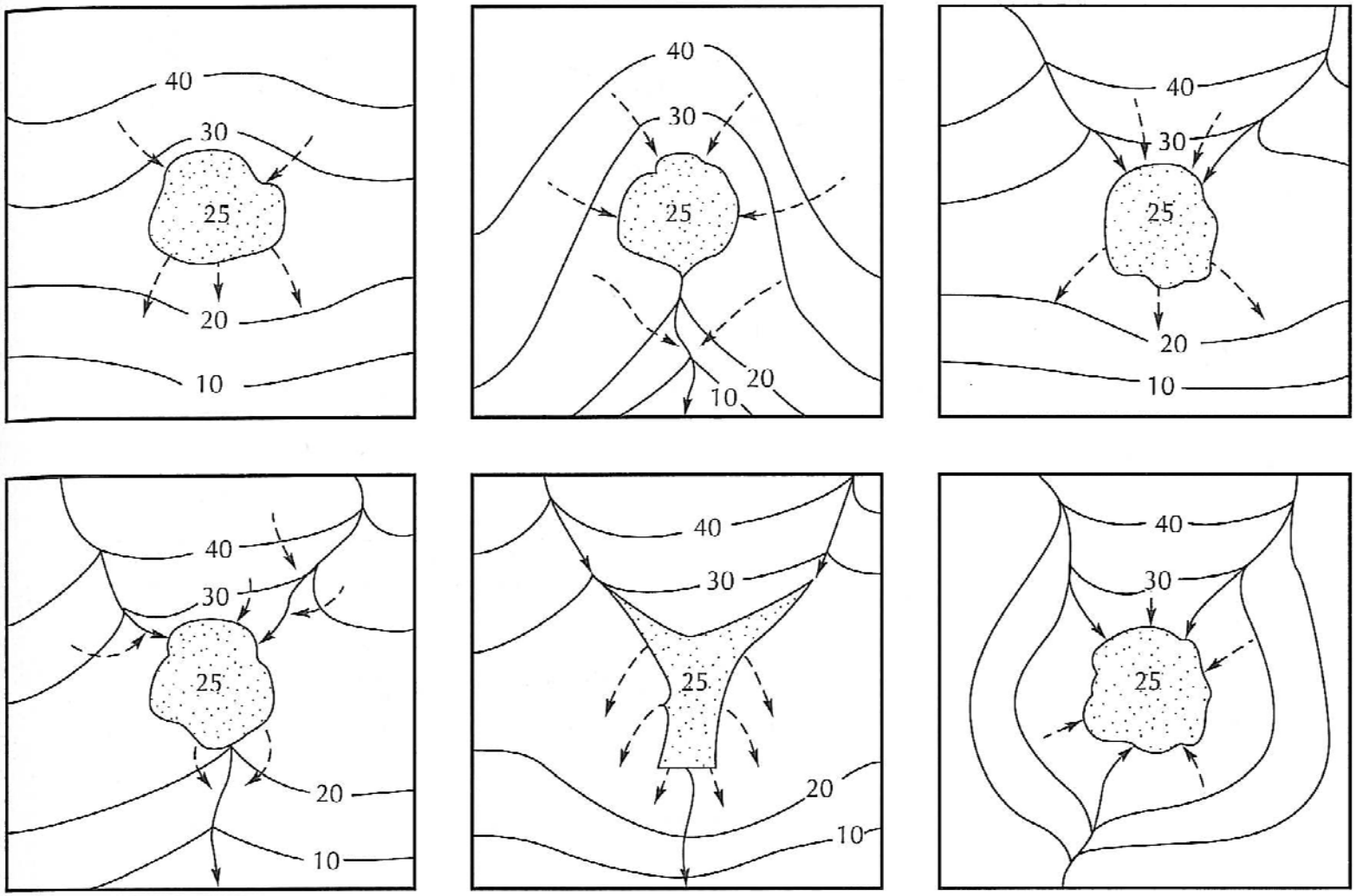


FIGURE 8.24 Some possible interactions among ground water, streams, and lakes and wetlands.

Fetter, 1995

Capture and Release Zones

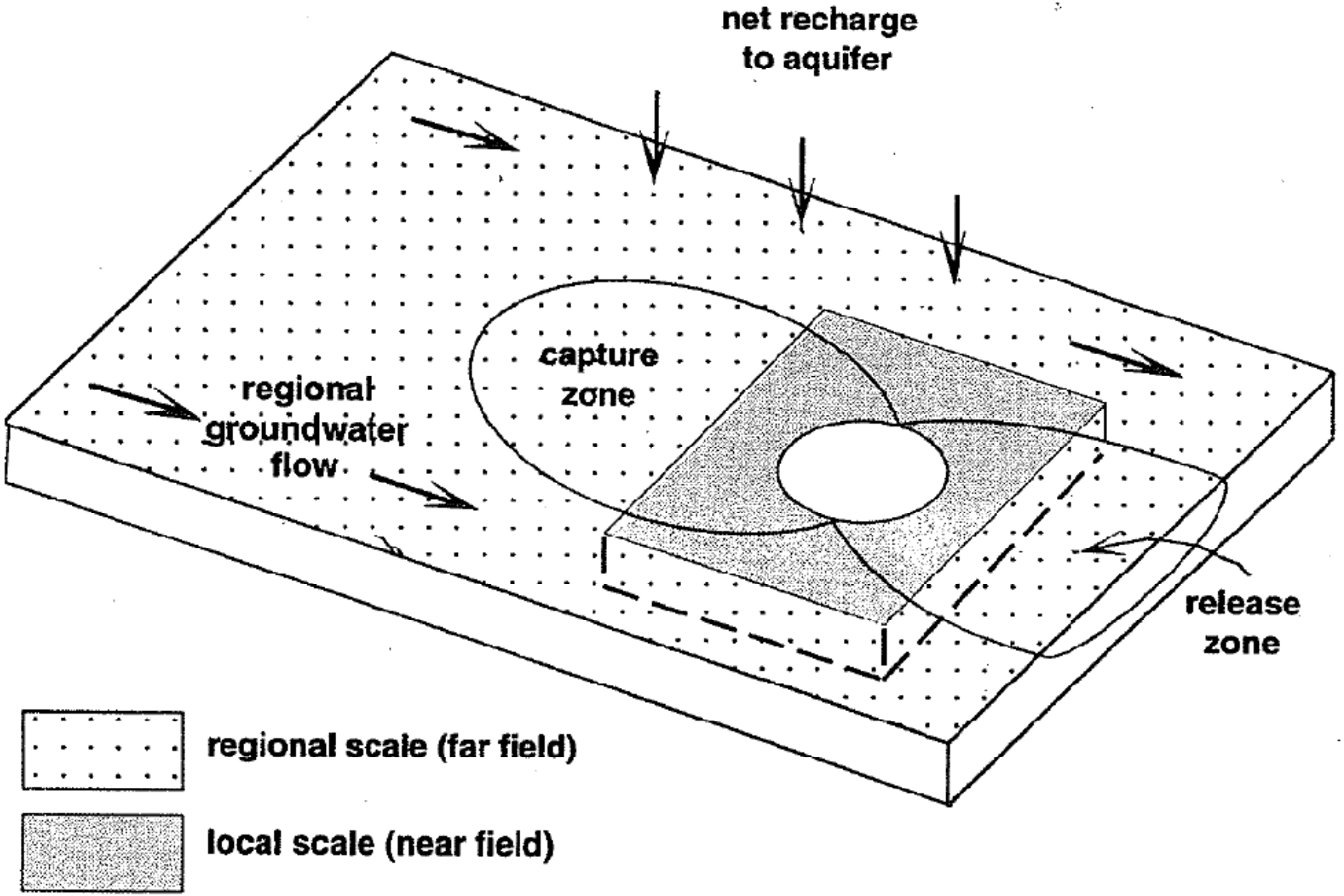


Figure 3.1.1 Relationship between regional scale and local scale

Wetlands of the Swan Coastal Plain, (1994)

Some Common Complexities of Wetland Hydrogeology

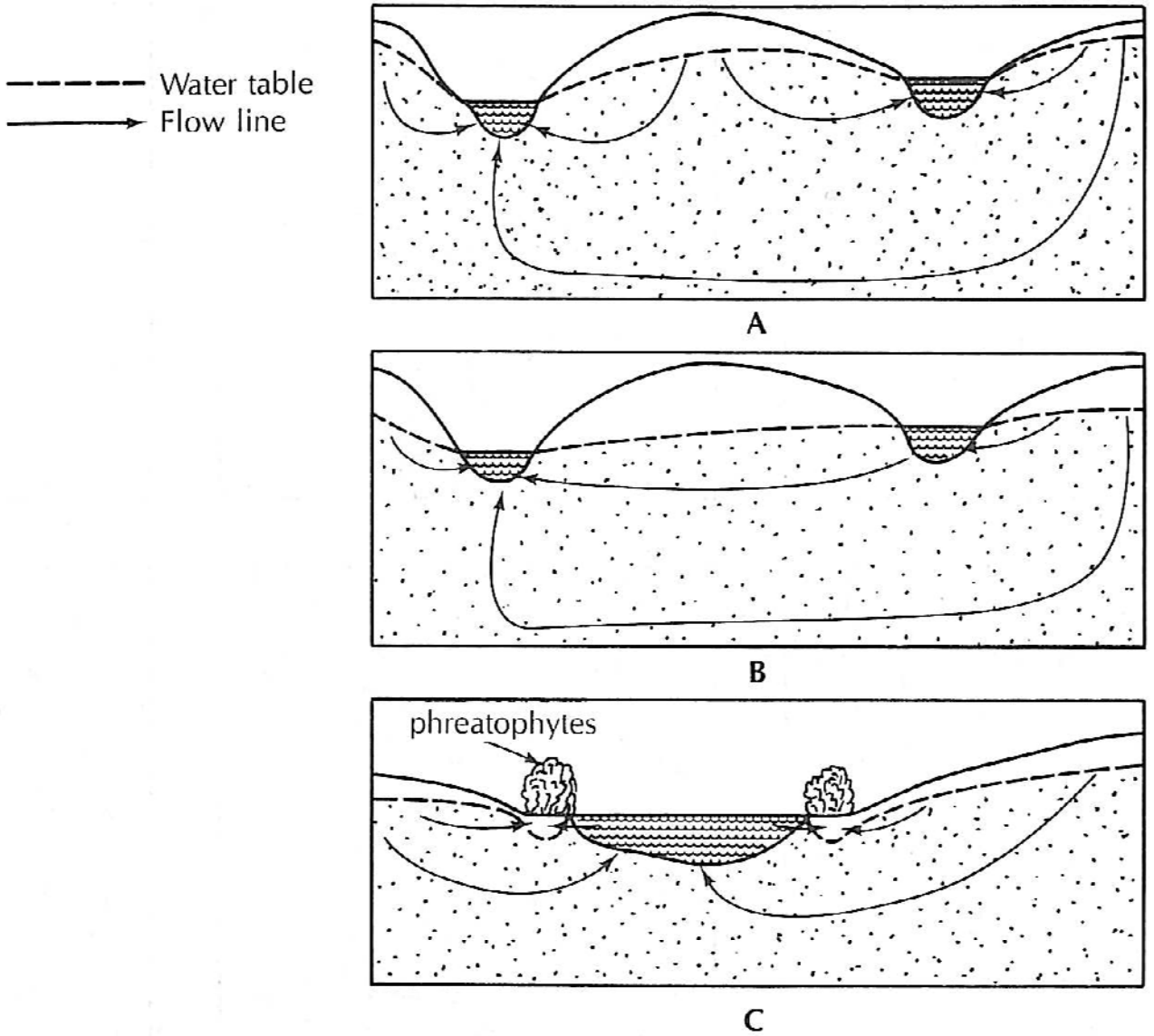
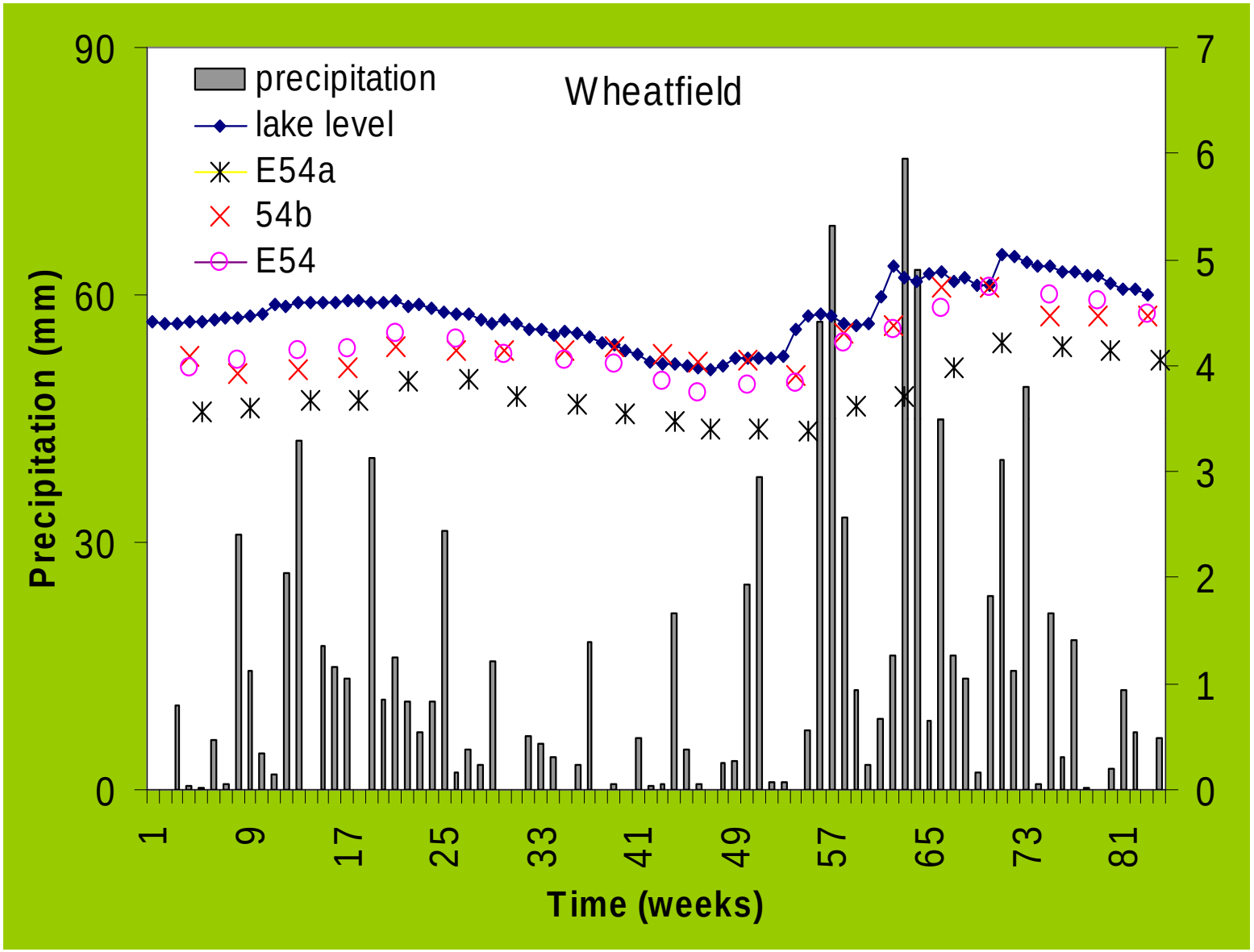


FIGURE 8.25 Ground-water–lake interactions: **A.** High water table and interlake ground-water divide. **B.** Low water table and no interlake divide. **C.** Depressed water table due to fringe of phreatophytes. Source: Redrawn from P. Meyboom, *Journal of Hydrology* 5 (1967): 117–42. Used with permission of Elsevier Scientific Publishing Company, Amsterdam.

Fetter, 1995

Lake Wheatfield - Esperance

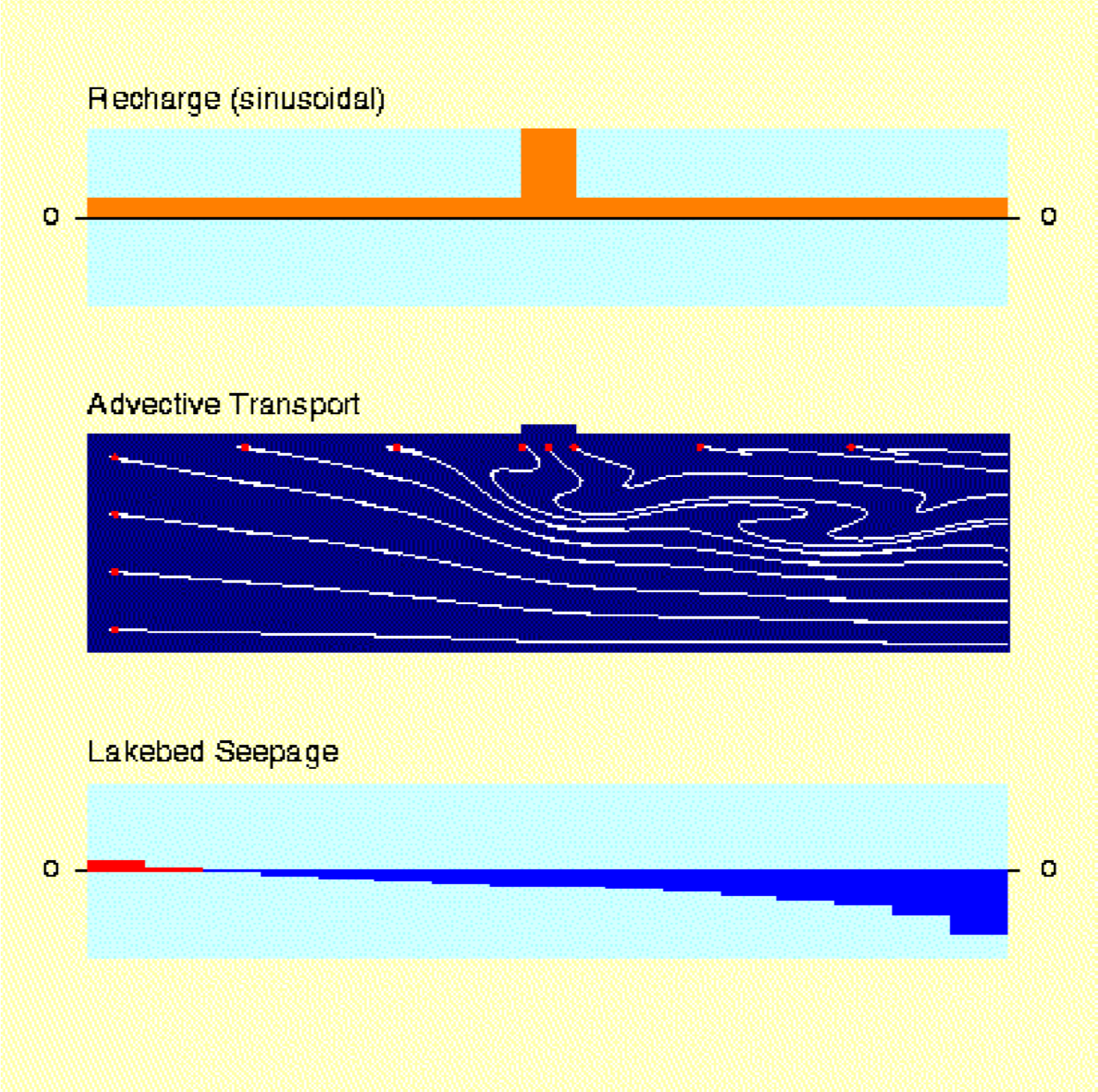


Temporal variations in the local groundwater flow system

Lake level is generally higher and reversal occurs in summer

Reynolds, 1998

- Recharge is supplied through rainfall on the ground surface and infiltration from the lake bed
- GW flow is left to right, with the lines representing flowlines
- Blue is positive to the aquifer



Townley, 2005

Wetland Water Budget/Balance

- The wetland water balance is essentially the balance of the inflows and outflows of water in the wetland
- This balance of inflows and outflows is one the most significant factors affecting the type, functions, and species composition of wetlands
- If the values can be quantified, simple balances can be used for managerial decision, future forecasting, etc.
- Useful in generation of models. Simple water balance models are one of the first types of models used in an impact assessment

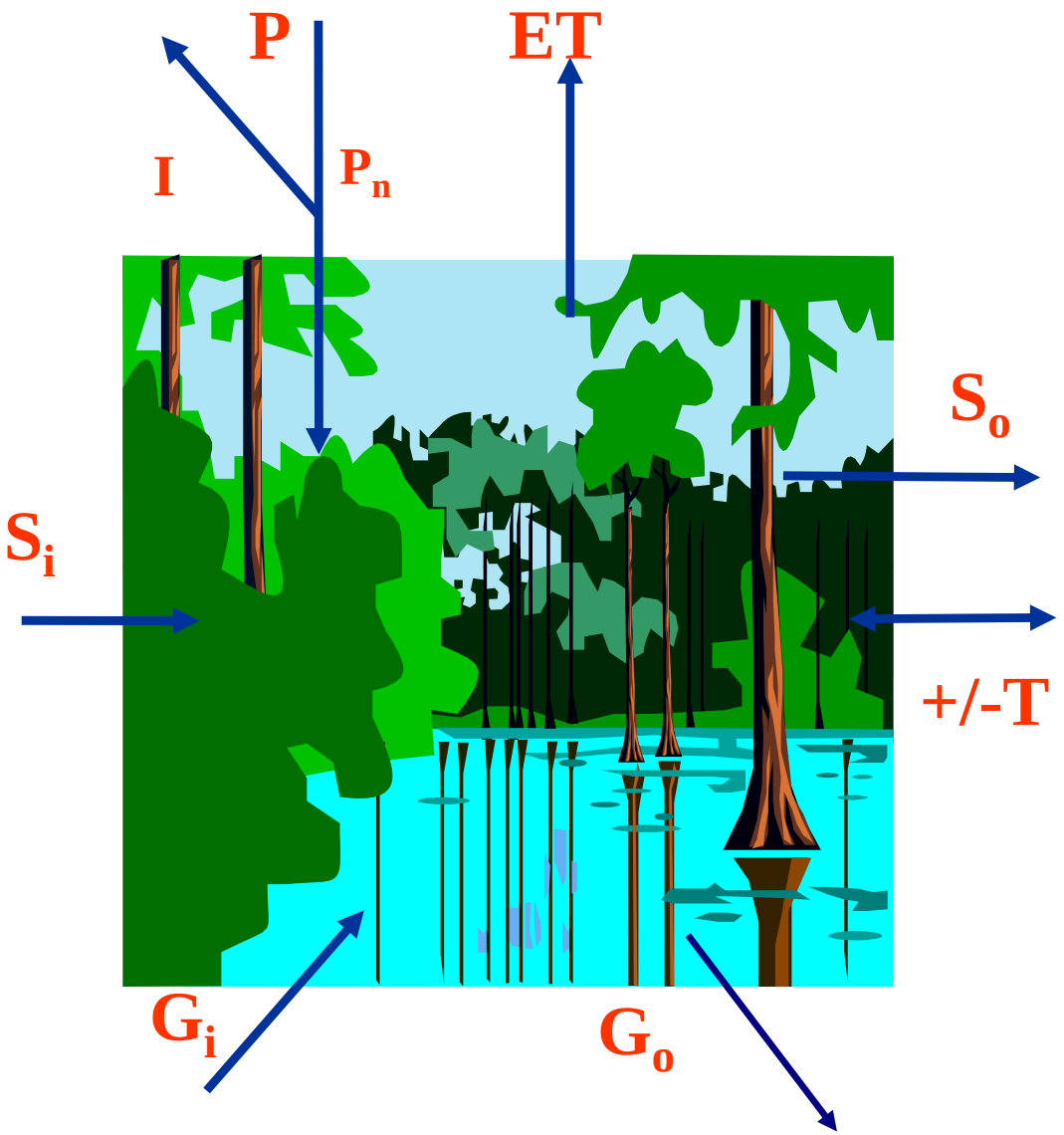
Wetland Water Budgets (Cont'd)

$$\Delta V/\Delta t = P_n + S_i + G_i - ET - S_o - G_o \pm T$$

Where:

- V = the volume of water storage in the wetland
- Δt = the change in storage over time
- P_n = net precipitation (total precipitation - interception in mm)
- S_i = surface inflows (volume per unit time)
- G_i = groundwater inflows (volume or volume per unit time)
- ET = evapotranspiration (mm per unit time) may calculate independently
- S_o = surface outflows (m3 per storm event or unit time)
- G_o = groundwater outflows (volume or volume per unit time)
- T = tidal inflow (+) or tidal outflow (-) (volume or volume per unit time)

Wetland Water Budgets (Cont'd)



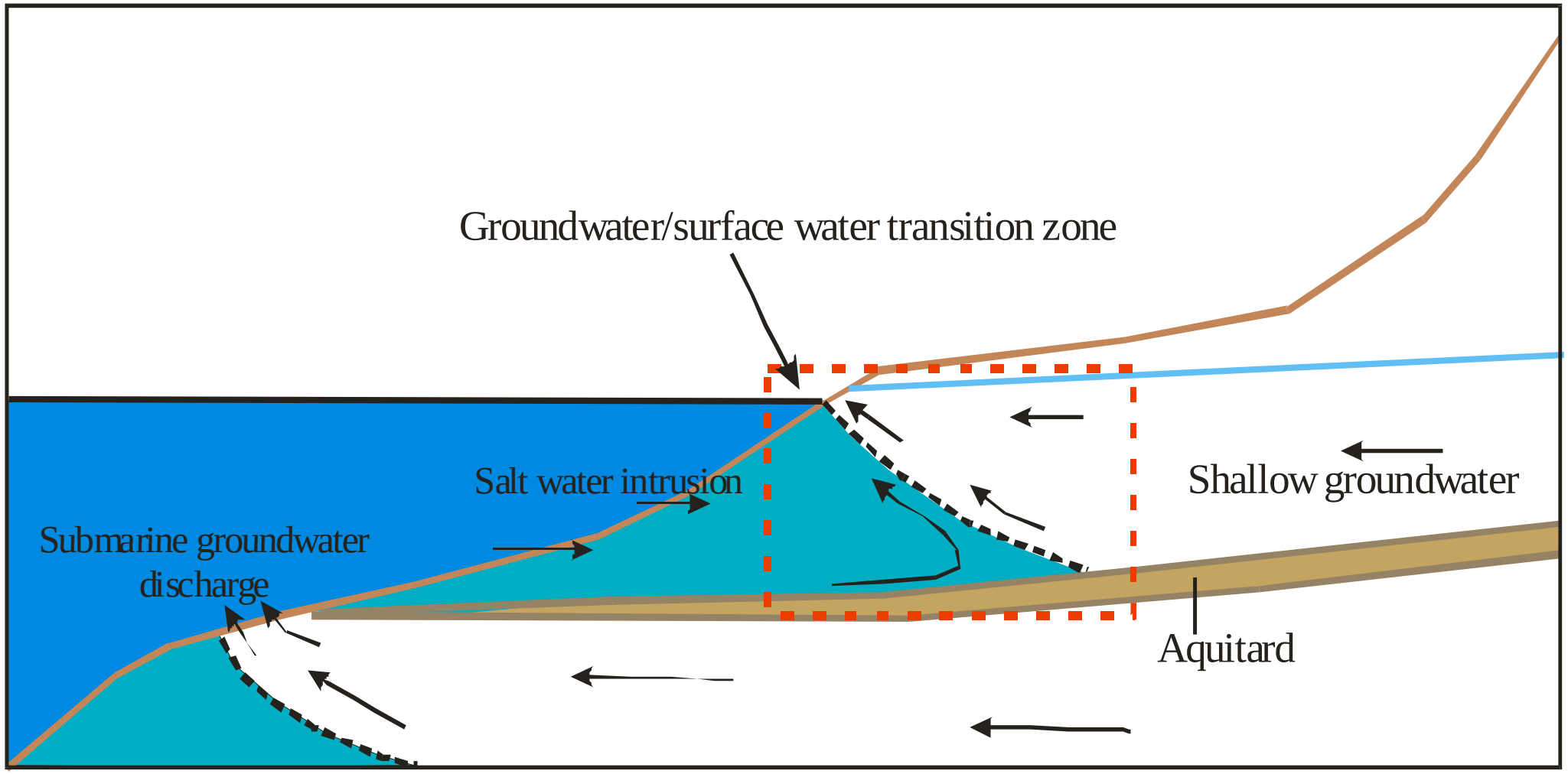
Solute Balances

- Given that all the inputs and outputs from a wetland system can be defined:

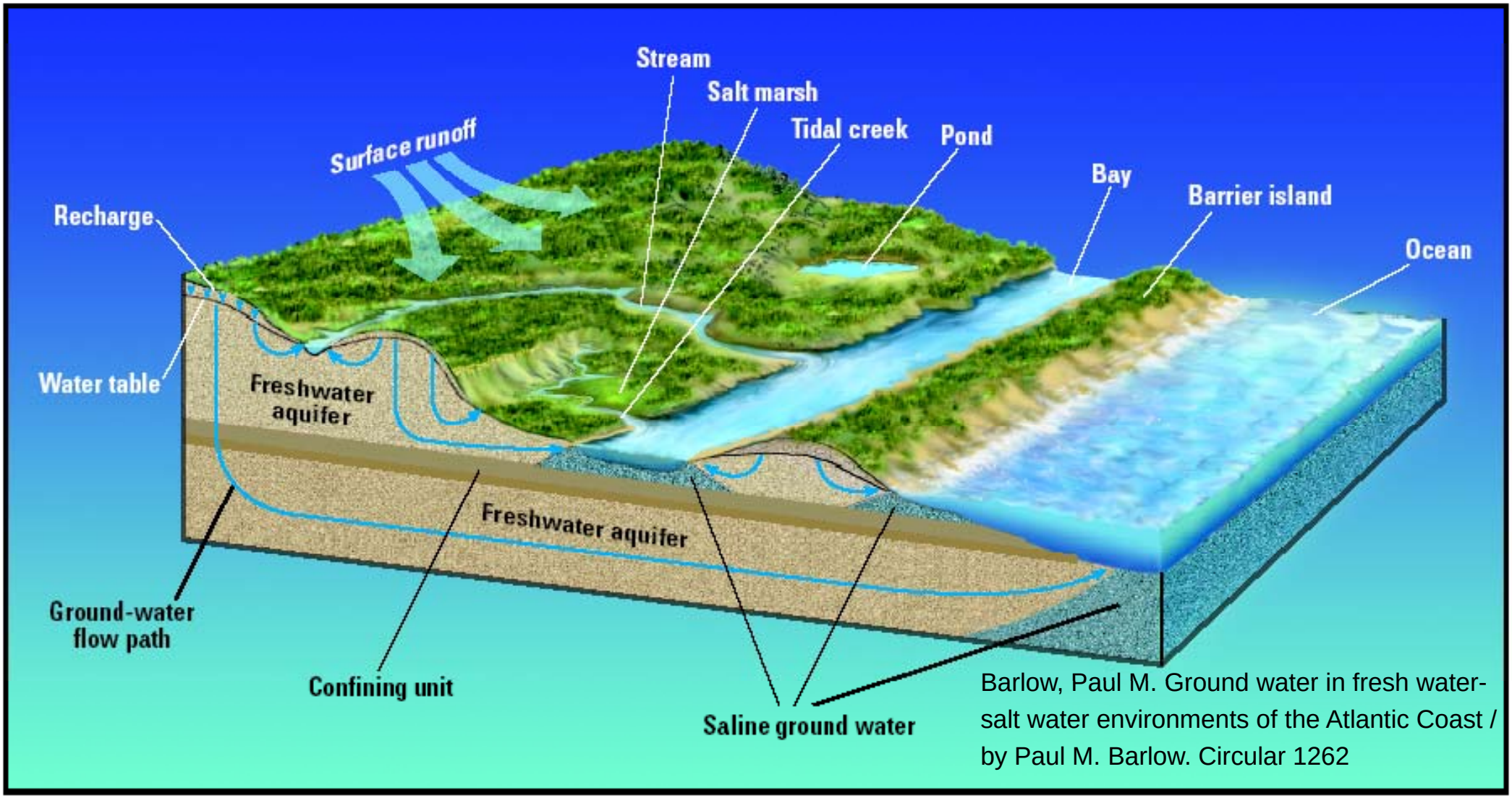
$$\frac{dV}{dt} = G(t)_i + P(t) + S_i(t) - G_o(t) - S_o(t) - E_o(t) + /- T$$

Gi and Si - groundwater and surface inflow
Go and So-groundwater and surface outflow
P and E - precipitation and evaporation
V - volume of lake
t – time
T – tidal inputs and outputs

Ocean Discharge and Interaction

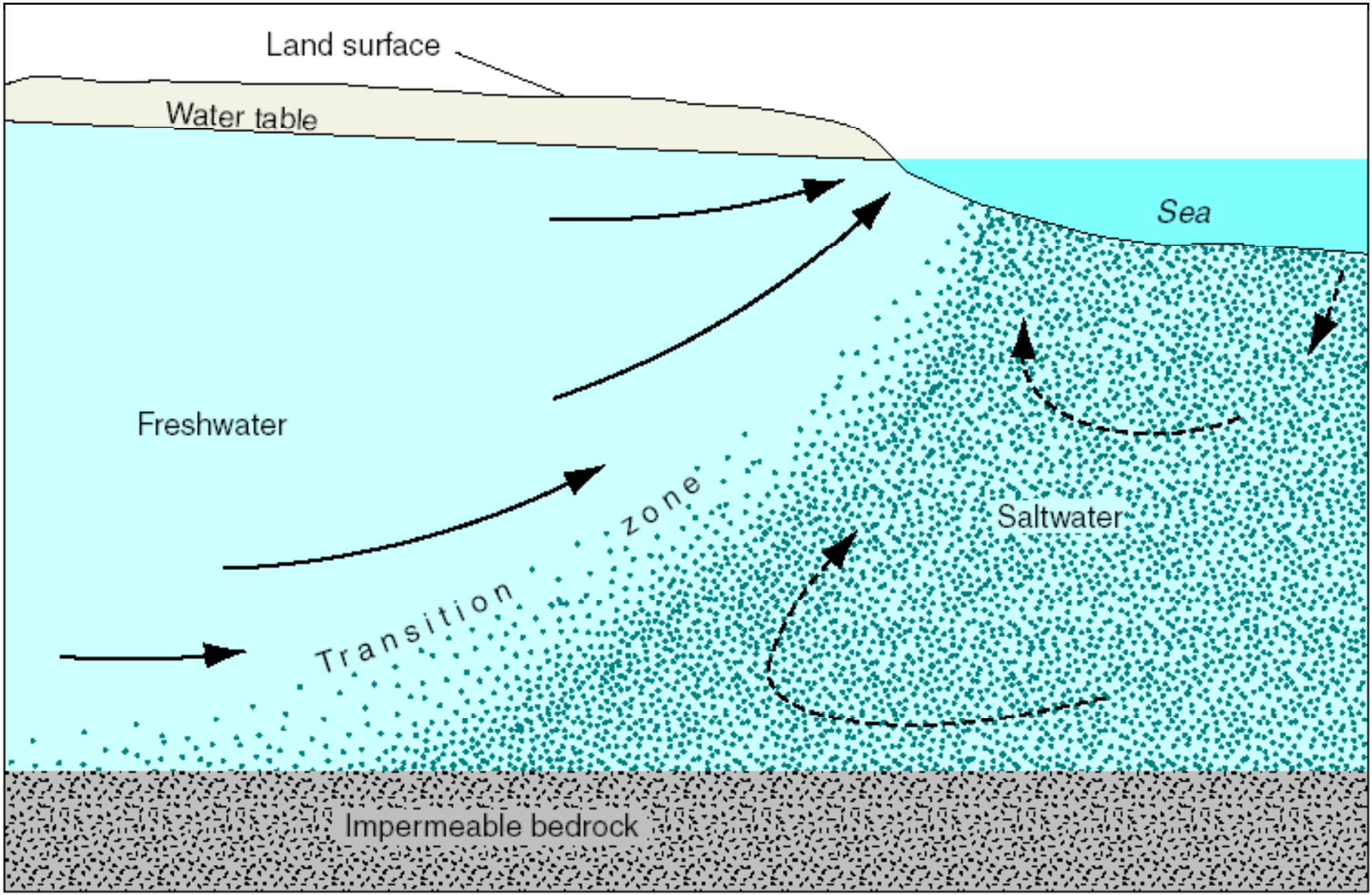


Coastal SW/GW Interaction Conceptual Model



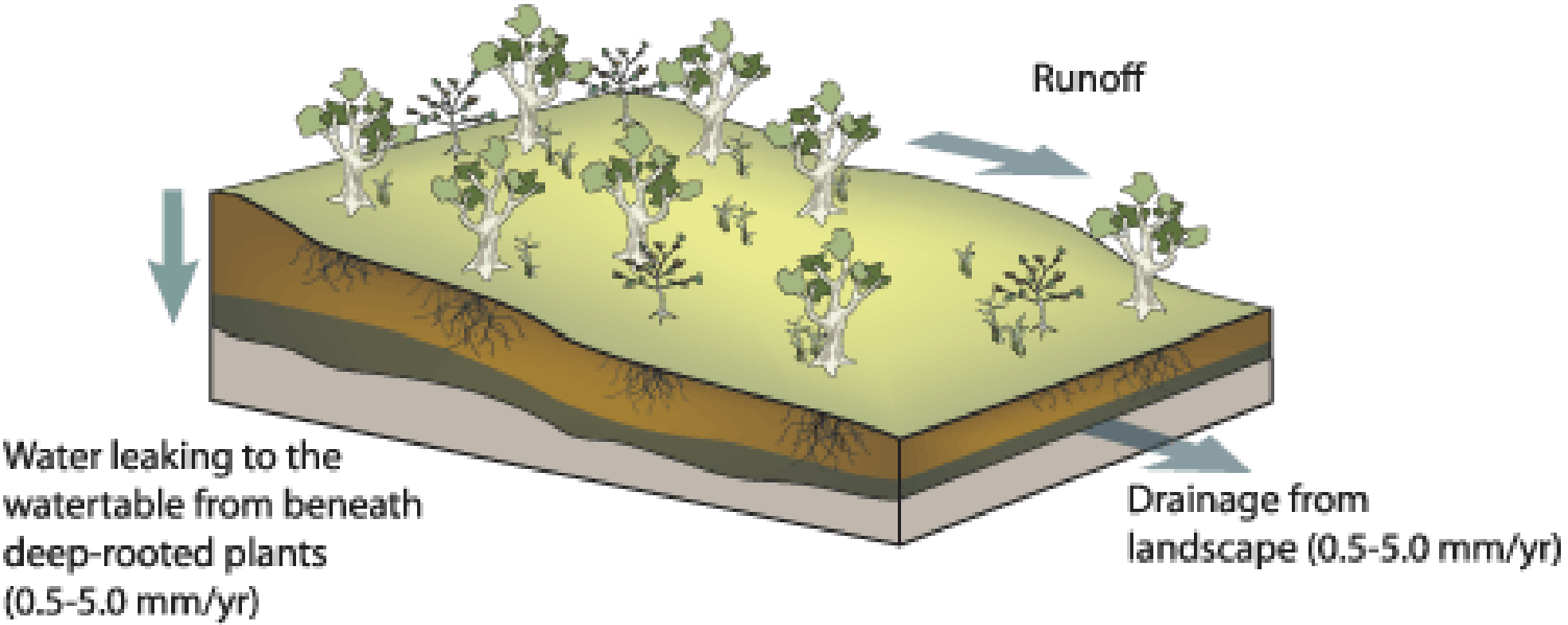
Barlow, Paul M. Ground water in fresh water-salt water environments of the Atlantic Coast / by Paul M. Barlow. Circular 1262

Not a Sharp Interface - Diffuse

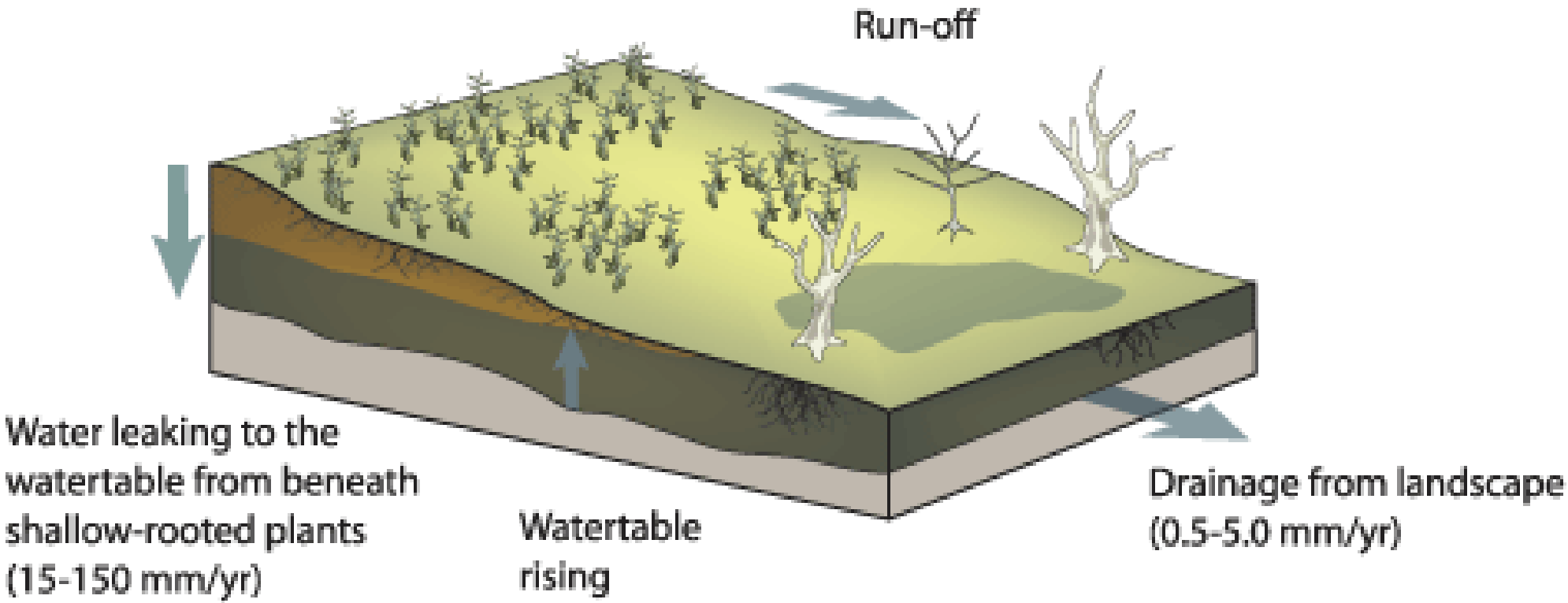


Barlow, Paul M. Ground water in fresh water-salt water environments of the Atlantic Coast / by Paul M. Barlow. Circular 1262

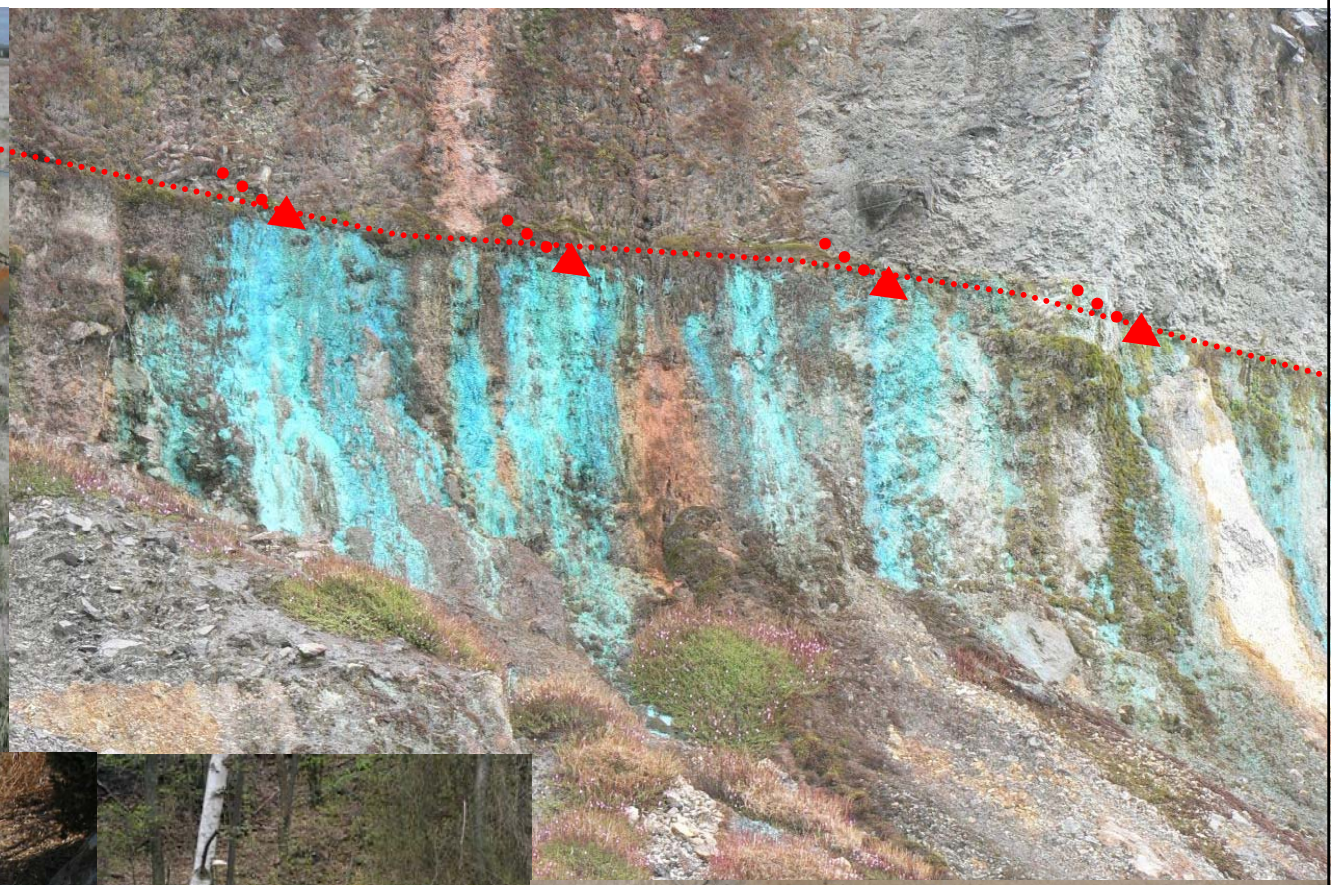
Water Balance Variation - Salinisation

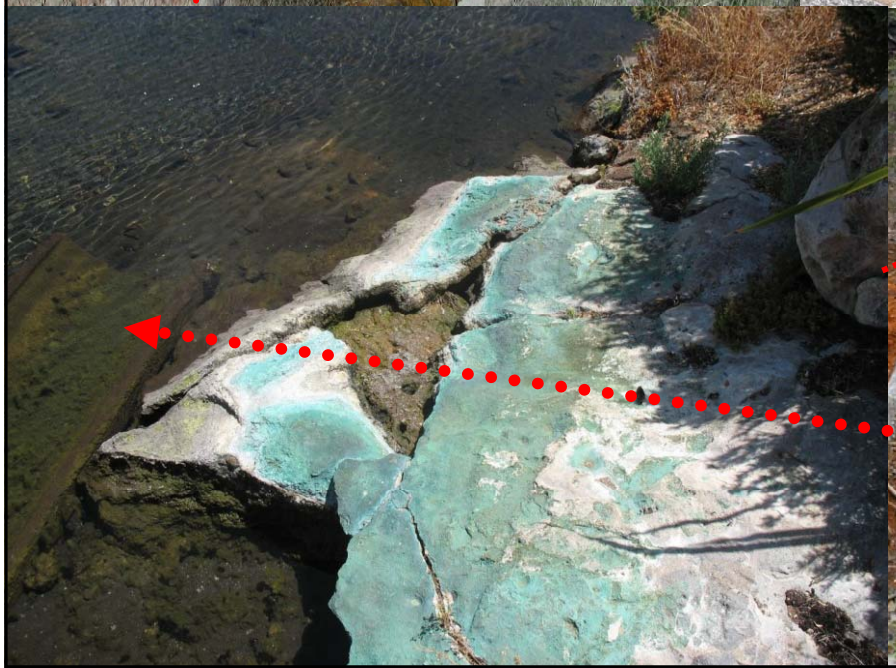


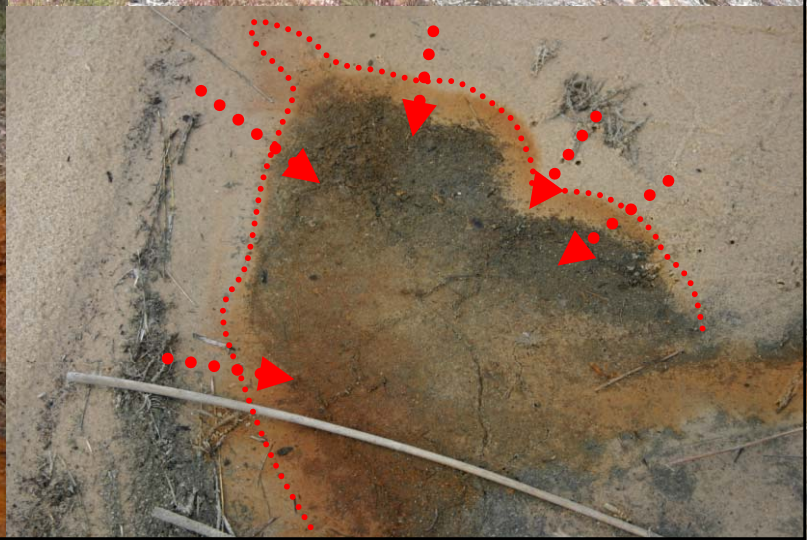
Seepages can disappear or be created based on topographic variations, landuse, climate, or other water balance altering issues. A classic example of appearing seepages is the effect of land clearing in the wheatbelt. Groundwater pumping is an obvious way to reduce water levels and hence stop a seepage.


Run-off
Water leaking to the watertable from beneath shallow-rooted plants (15-150 mm/yr)
Watertable rising
Drainage from landscape (0.5-5.0 mm/yr)

Groundwater Discharge – Precipitates

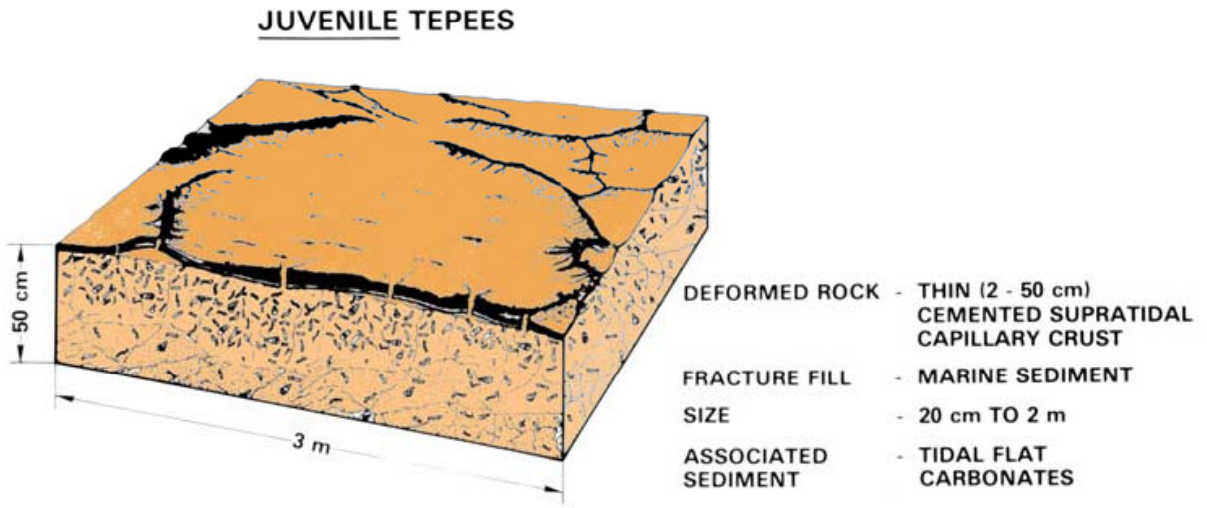


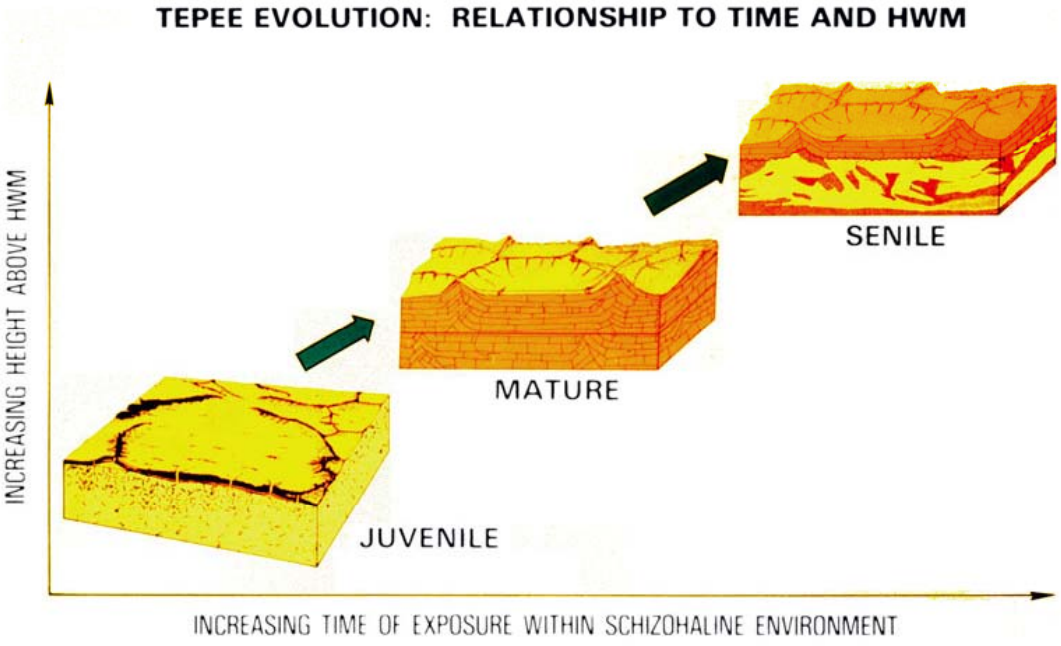




Groundwater Discharge - Biotic

Physical Discharge Evidence - Tepee Structures





General Principles

1. We understand that groundwater and surface water are usually interconnected and interchangeable
   - GW becomes SW, and SW becomes GW
2. Not recognised
   - results in double accounting and double allocation
3. Not recognised because of long time lag
   - commonly decades
4. Major growth of GW uses in 1980s and 1990s not yet felt
5. In many parts of Australia we have capped SW, but can still drill a bore on the banks of a river and call it GW and get it licensed

Evans, 2005

General Principles (cont)

6. As distance between bore and river increases, the time delay of impact is proportional to d^2
   ie 10 X increase in distance = 100 X time delay
7. Depending upon hydrogeological features, it may be argued that all groundwater use in a catchment results in reduced stream flow, ie 100% impact, except:
   - discharge to ET
   - discharge to oceans
   - flow to another groundwater system
   - disconnected streams
   - recharge to deep system

Evans, 2005

Summary

1. Numerous types SW/GW interactions exist, generally some site specific information is required to understand the interactions in any detail
2. SW/GW interactions change through time and space. Get a few years worth of data before making any real management decisions
3. Water balances are a good preliminary tool for assessing management feasibility
4. Lack of understanding of groundwater surface water interaction has led to potentially large scale “double allocation”