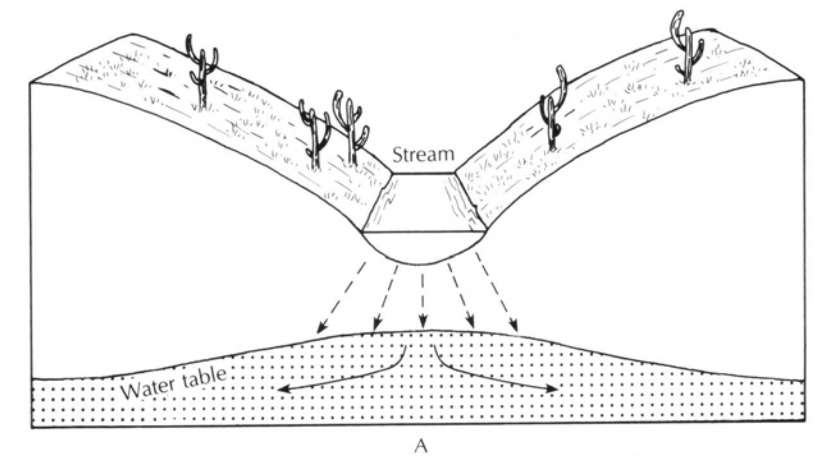
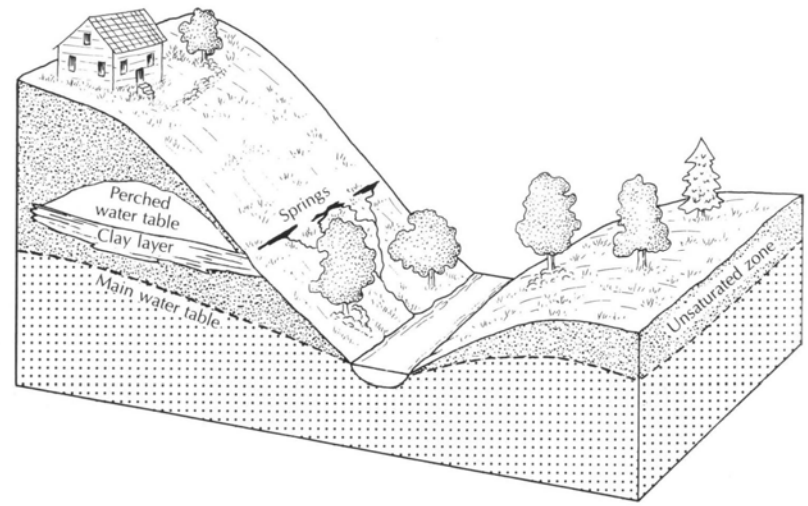
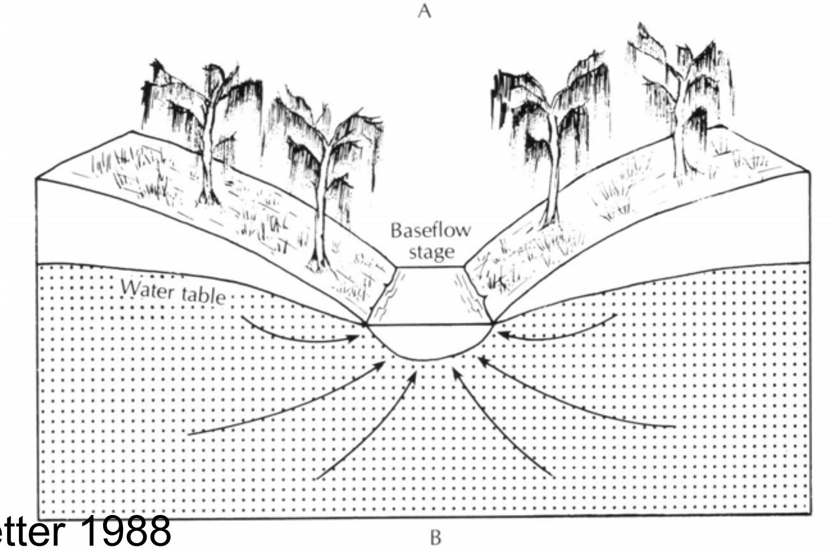
$$\Delta V/\Delta t = P_n + S_i + G_i - ET - S_o - G_o \pm T$$

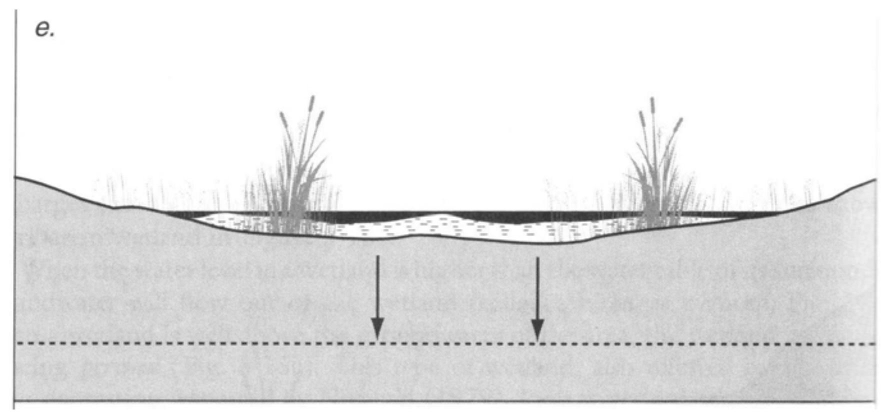
Groundwater & Wetlands

Interactions between wetlands and groundwater:
Discharge, seep, recharge, perched, isolated









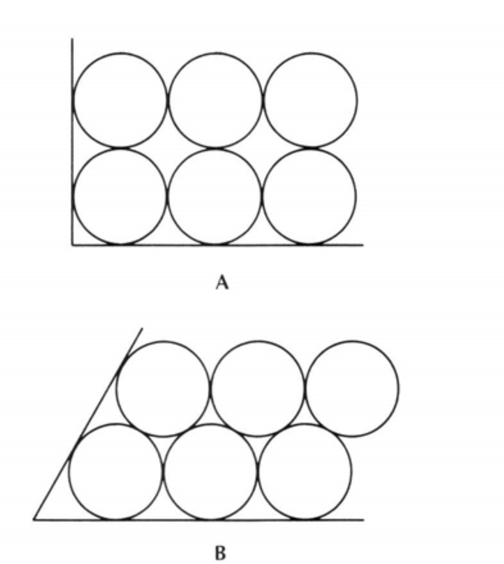
Fetter 1988

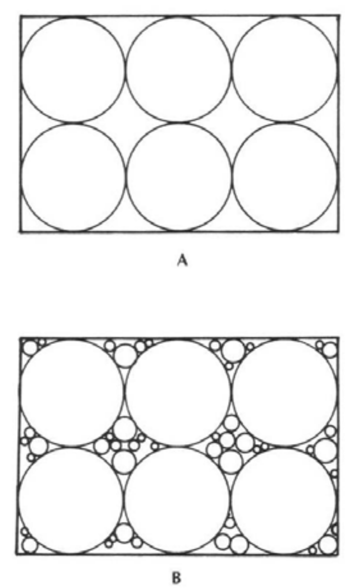
$$\Delta V/\Delta t = P_n + S_i + G_i - ET - S_o - G_o \pm T$$

Groundwater Flow

Flow rate through geologic material controlled by:

- porosity (sediment or rock type)
- grain sorting
- hyraulic gradient (slope)
- hydraulic conductivity (porosity and viscosity (temperature))
  (k values typically for pure water at 15.6 C (60 F))





Fetter 1988

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

Groundwater Flow

Hydraulic conductivity (k) values

Material	Hydraulic conductivity (cm/sec)
Clay	$10^{-9} - 10^{-6}$
Silt, sandy & clayey silts	$10^{-6} - 10^{-4}$
Silty sand, fine sand	$10^{-5} - 10^{-3}$
Well-sorted sand	$10^{-3} - 10^{-1}$
Well-sorted gravel	10^{-2} - 1

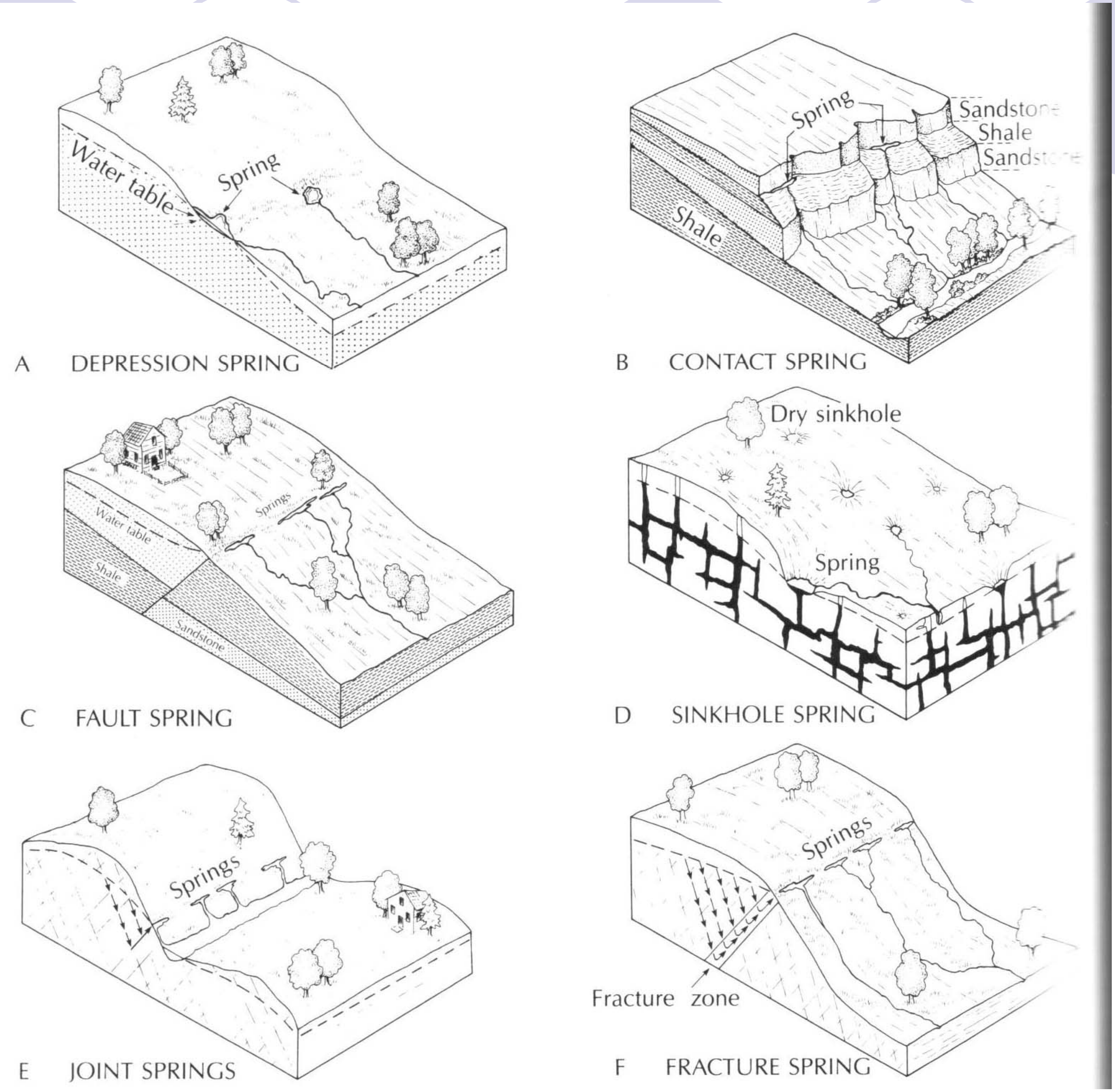
Rock:

Sedimentary (sandstone, etc), crystalline (igneous, metamorphic, chemically-preciptated rock (limestone, dolomite, etc.))

organic soils 2×10^{-7} / 8×10^{-3}

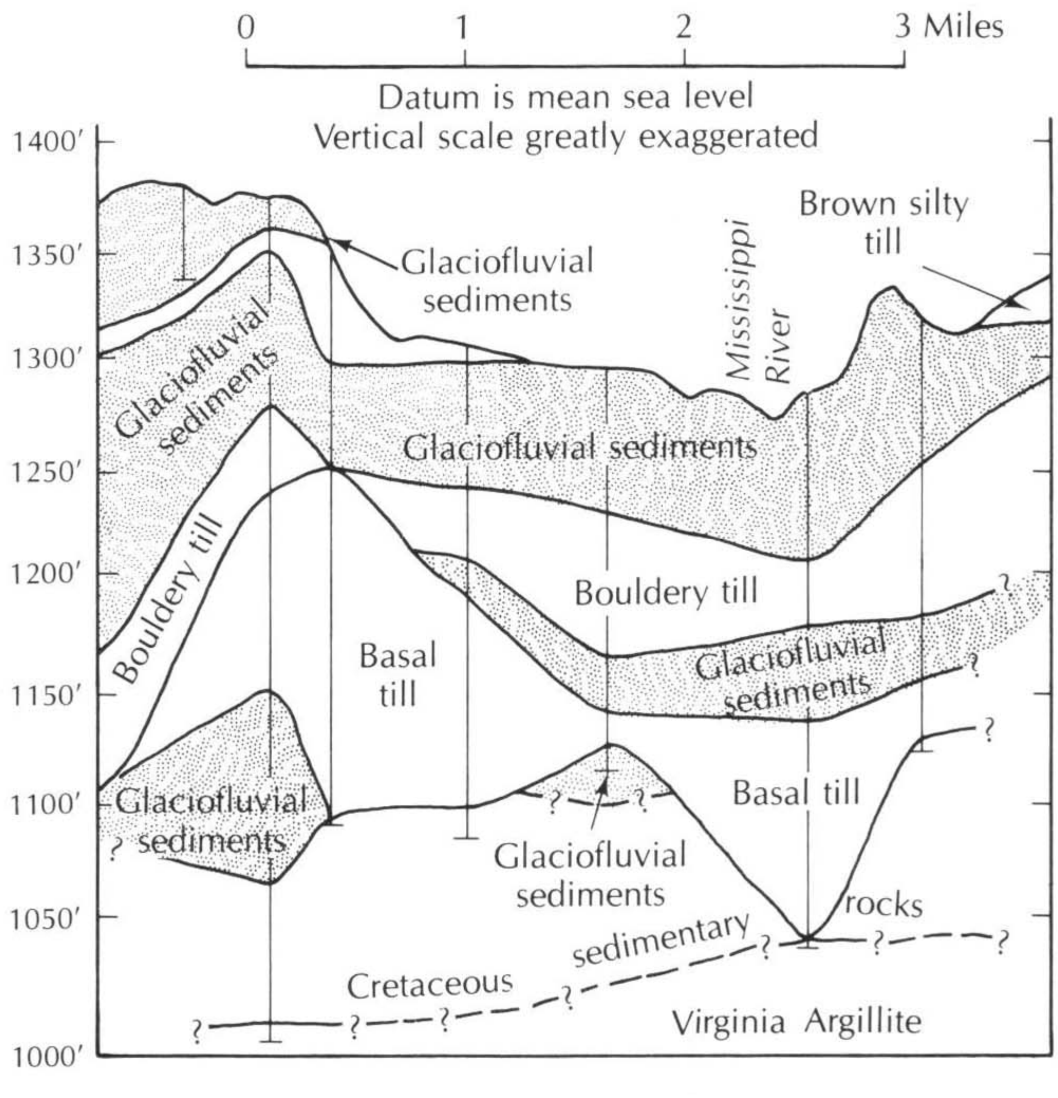
(k values typically for pure water at 15.6 C (60 F))

Groundwater Flow in Rock



Fetter 1988

Iron Range Geology



Fetter 1988

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

Groundwater Flow

Darcy's law:

$G = kA_x s$

G = groundwater flow rate (cm^3/s)

k = hydraulic conductivity (cm/s)

A_x = cross sect area (cm^2)

s = hydraulic gradient (slope)

Material	Hydraulic conductivity (cm/sec)
Clay	$10^{-9} - 10^{-6}$
Silt, sandy & clayey silts	$10^{-6} - 10^{-4}$
Silty sand, fine sand	$10^{-5} - 10^{-3}$
Well-sorted sand	$10^{-3} - 10^{-1}$
Well-sorted gravel	10^{-2} - 1

organic soils

2×10^{-7}
8×10^{-3}

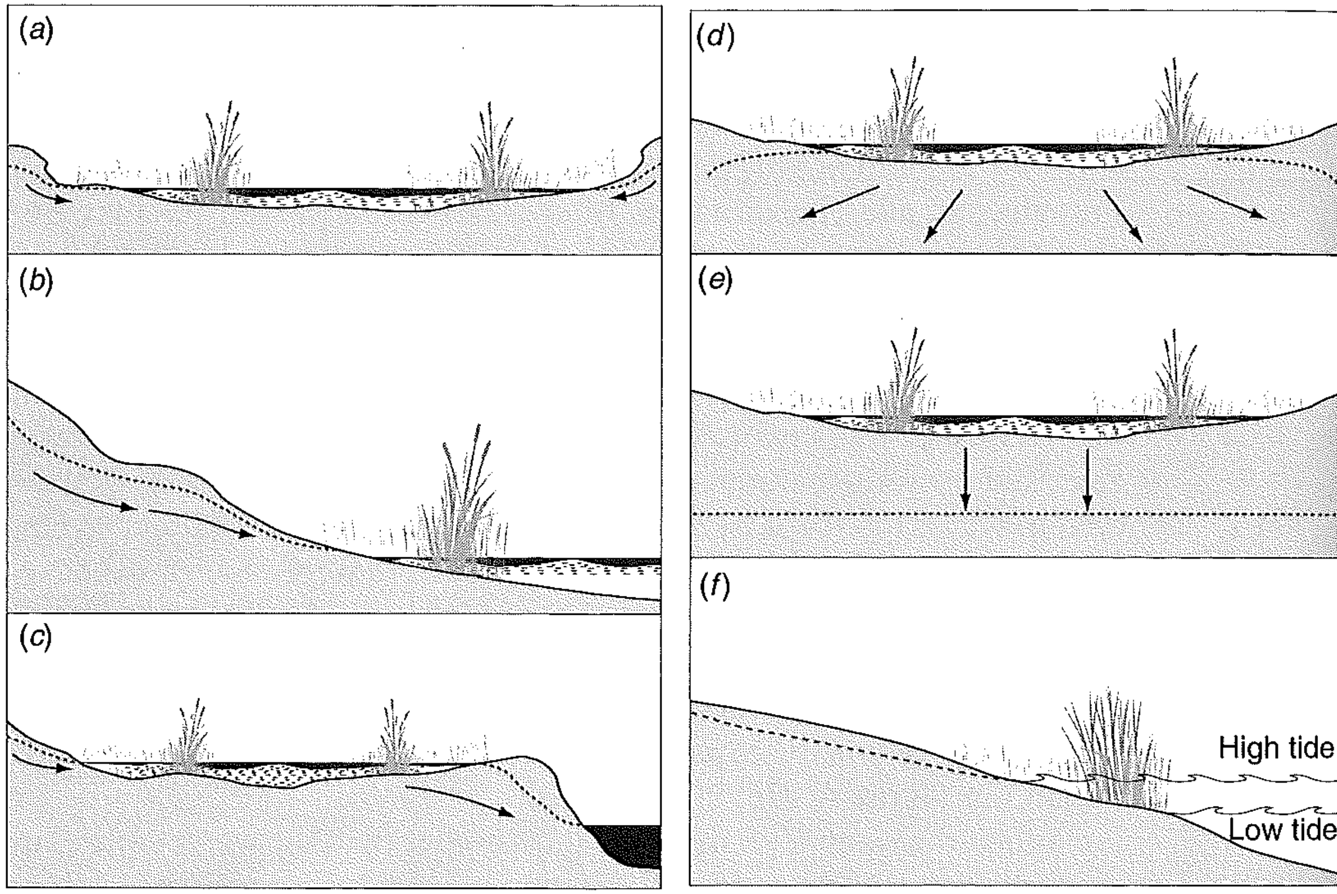
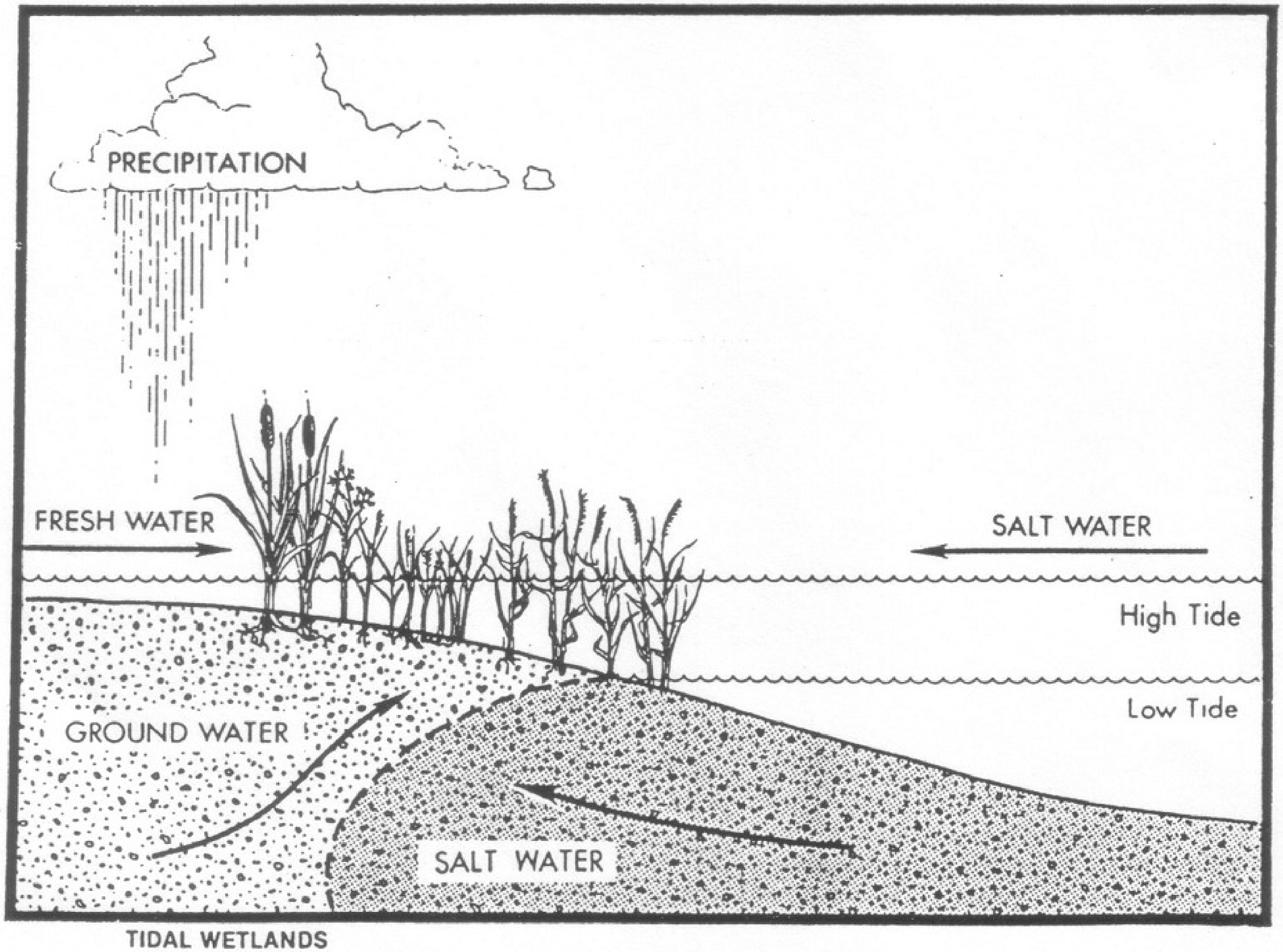


Figure 4.15 Possible discharge–recharge interchanges between wetlands and groundwater systems including (a) marsh as a depression receiving groundwater flow ("discharge wetland"); (b) groundwater spring or seep wetland or groundwater slope wetland at the base of a steep slope; (c) floodplain wetland fed by groundwater; (d) marsh as a "recharge wetland" adding water to groundwater; (e) perched wetland or surface water depression wetland; (f)˜groundwater flow through a tidal wetland. Dashed lines indicate groundwater level.

Human alteration of groundwater flow

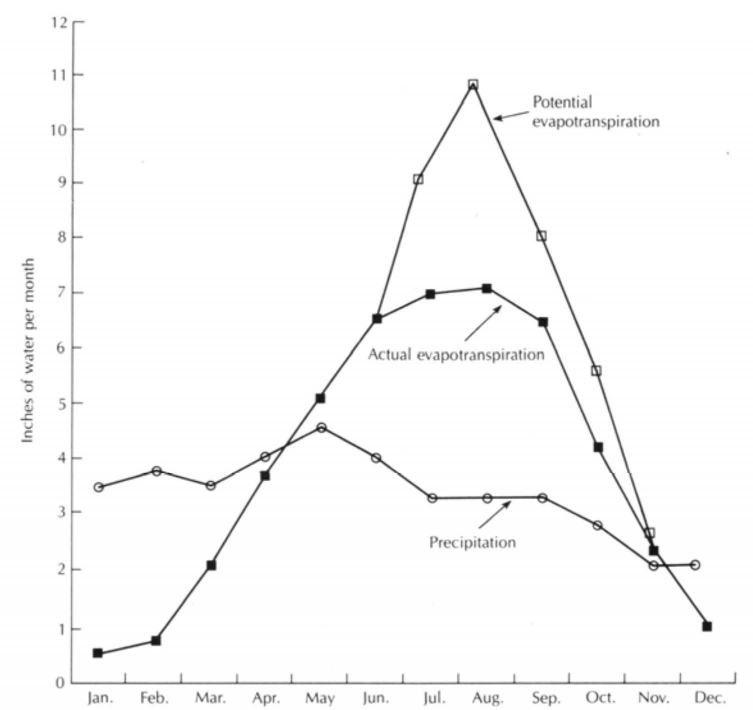


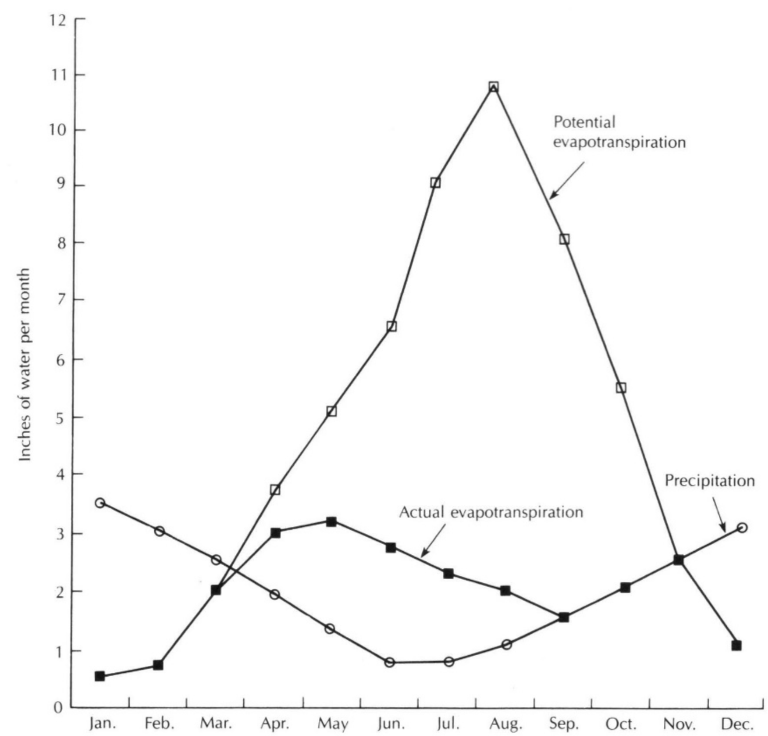
$$\Delta V/\Delta t = P_n + S_i + G_i - ET - S_o - G_o \pm T$$

Evapotranspiration

Dalton's law: evaporation is controlled by water vapor pressure differences between evaporative surfaces and air.

Transpiration is under more direct control of plants (stomates, photosynthetic pathway).



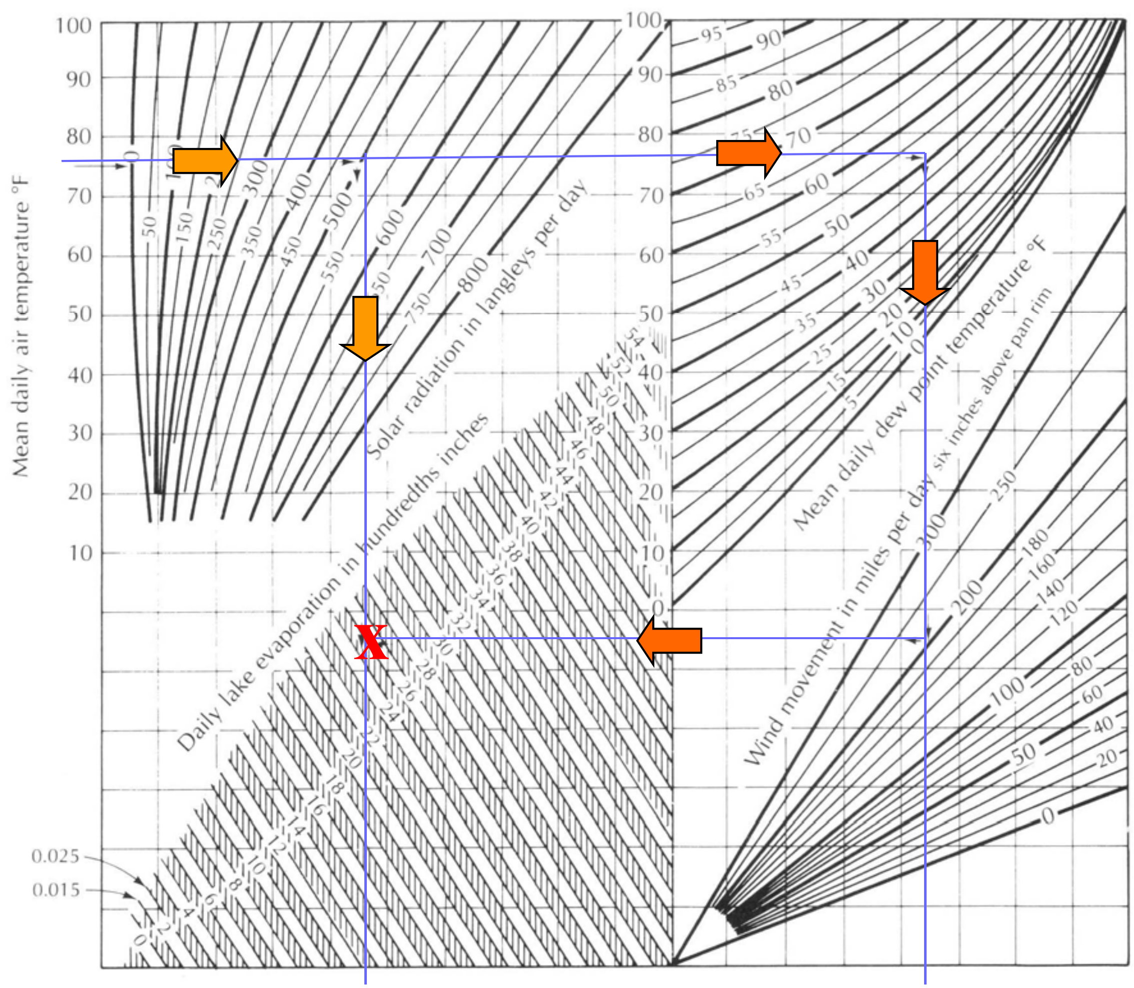


Fetter 1988

Jawitz, University of Florida, 2008

Evapotranspiration

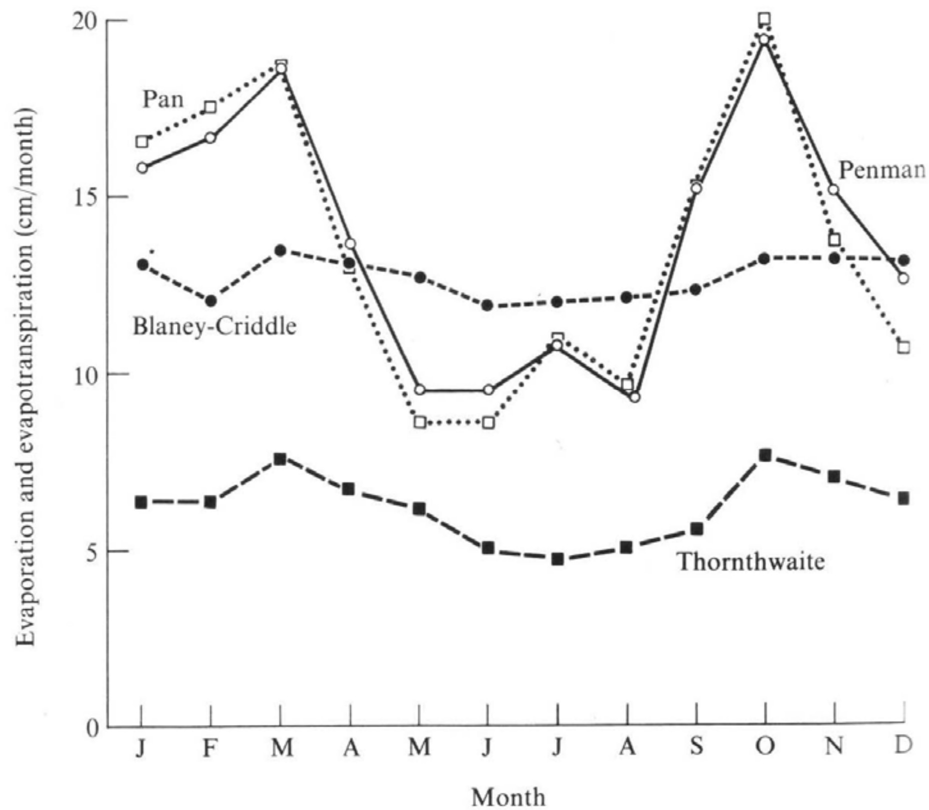
- Direct measurement:
  - pan evaporation
  - water vapor in chambers
- Inferred:
  - diurnal water level fluctuations
- Empirical equations:
  - evaporation nomograph



Fetter 1988

Evapotranspiration

- Empirical equations:
  - Penman: requires a lot of solar radiation information
  - Scheffe: also relies on solar radiation measurements
  - Thornthwaite: based only on monthly mean air temperatures
    - ignore influence of plant type, density, maturity, etc.
    - best for annual averages



Evapotranspiration Thornthwaite

$Et_i = 16(10T_i/I)^a$

$I = \Sigma (T_i/5)^{1.514}$ heat index

T_i = monthly avg temp

$a = (0.675I^3 - 77.1I^2 + 17{,}920I + 492{,}390) \times 10^{-6}$

PET correction factors

Corr $Et_i = Et_i$ x corr factor

Table 5-2 Correction factor for monthly sunshine duration for multiplication of the standard potential evapotranspiration from Figure 5-4.

LATITUDE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
60°N	0.54	0.67	0.97	1.19	1.33	1.56	1.55	1.33	1.07	0.84	0.58	0.48
50°N	0.71	0.84	0.98	1.14	1.28	1.36	1.33	1.21	1.06	0.90	0.76	0.68
40°N	0.80	0.89	0.99	1.10	1.20	1.25	1.23	1.15	1.04	0.93	0.83	0.78
30°N	0.87	0.93	1.00	1.07	1.14	1.17	1.16	1.11	1.03	0.96	0.89	0.85
20°N	0.92	0.96	1.00	1.05	1.09	1.11	1.10	1.07	1.02	0.98	0.93	0.91
10°N	0.97	0.98	1.00	1.03	1.05	1.06	1.05	1.04	1.02	0.99	0.97	0.96
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10°S	1.05	1.04	1.02	0.99	0.97	0.96	0.97	0.98	1.00	1.03	1.05	1.06
20°S	1.10	1.07	1.02	0.98	0.93	0.91	0.92	0.96	1.00	1.05	1.09	1.11
30°S	1.16	1.11	1.03	0.96	0.89	0.85	0.87	0.93	1.00	1.07	1.14	1.17
40°S	1.23	1.15	1.04	0.93	0.83	0.78	0.80	0.89	0.99	1.10	1.20	1.25
50°S	1.33	1.19	1.05	0.89	0.75	0.68	0.70	0.82	0.97	1.13	1.27	1.36

Vegetation: increase or decrease water loss?

Wetland/veg type	Evapotranspiration (% of evap)
Bog	< winter, > summer
Bog	88 – 121
Pothole	90
Depression	180
Cypress dome pond	60 – 80
Cypress pond	<

ET effects on wetland water table

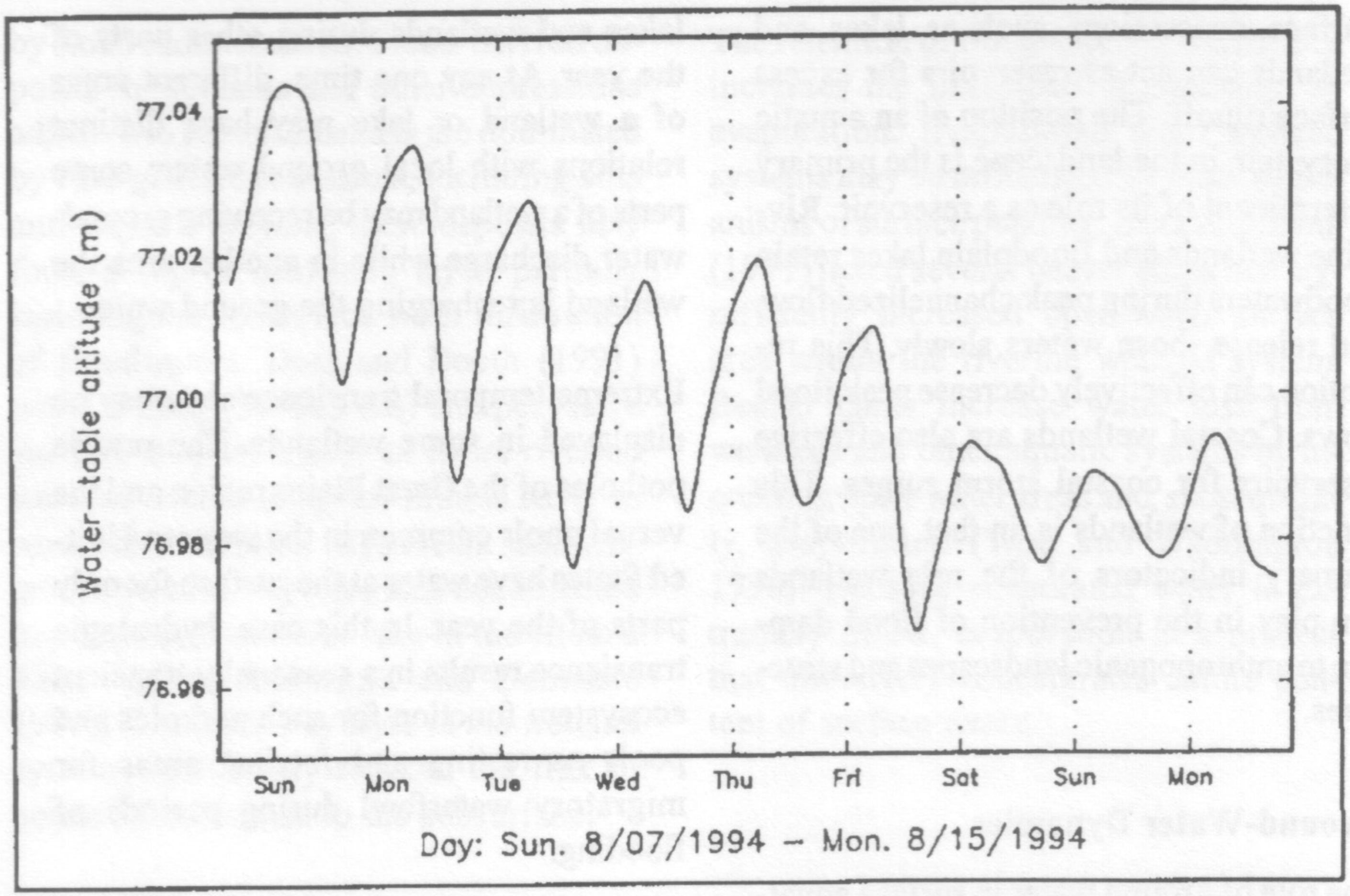


Figure 1. Ground-water well hydrograph from the Great Bog wetland system in central Maine. The hydrograph illustrates diurnal declines of the water table due to evapotranspirative discharge and partial rebound of the water table at night.

Doss 1995

Forest management effects on hydrology

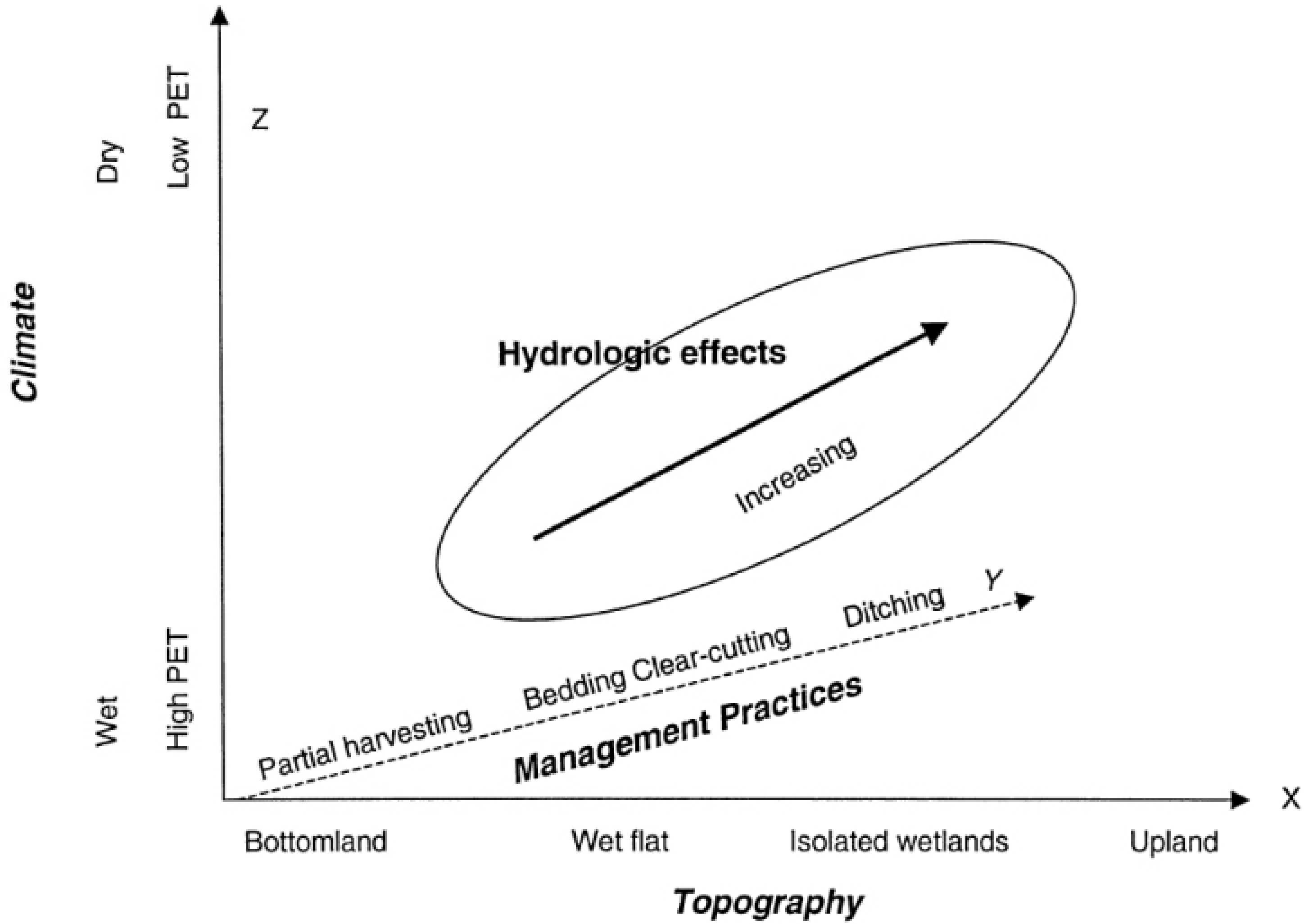


Fig. 1. A conceptually generalized model for the effects of management on wetlands hydrology, southern US.

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

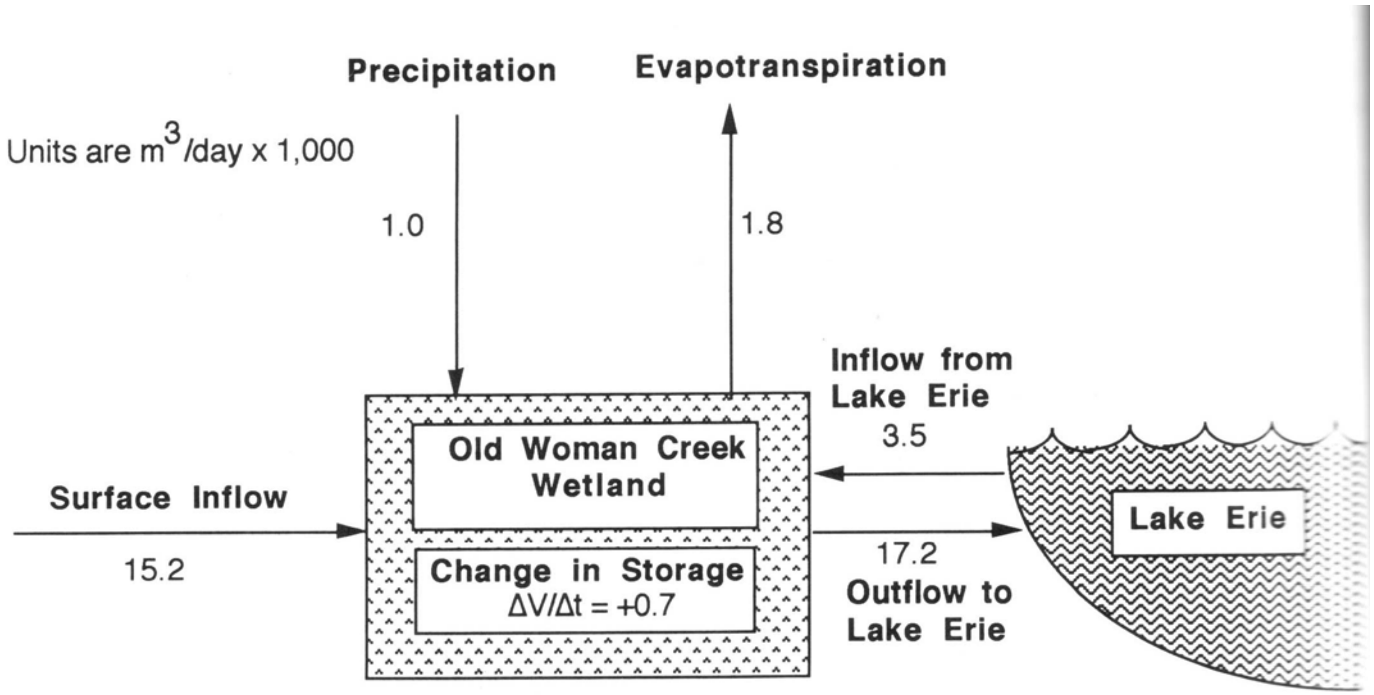


FIG. 8. Approximate water budget for Old Woman Creek for March through November, 1988 (from Mitsch and Reeder 1992).