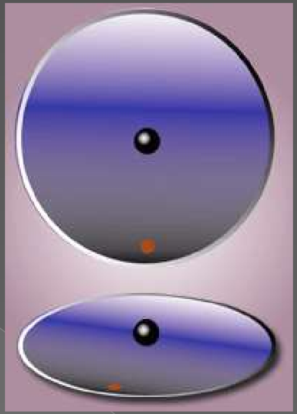
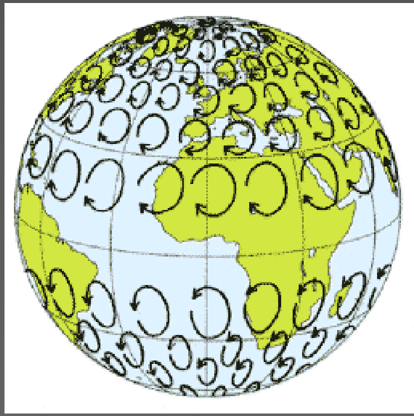
Flow and dispersion

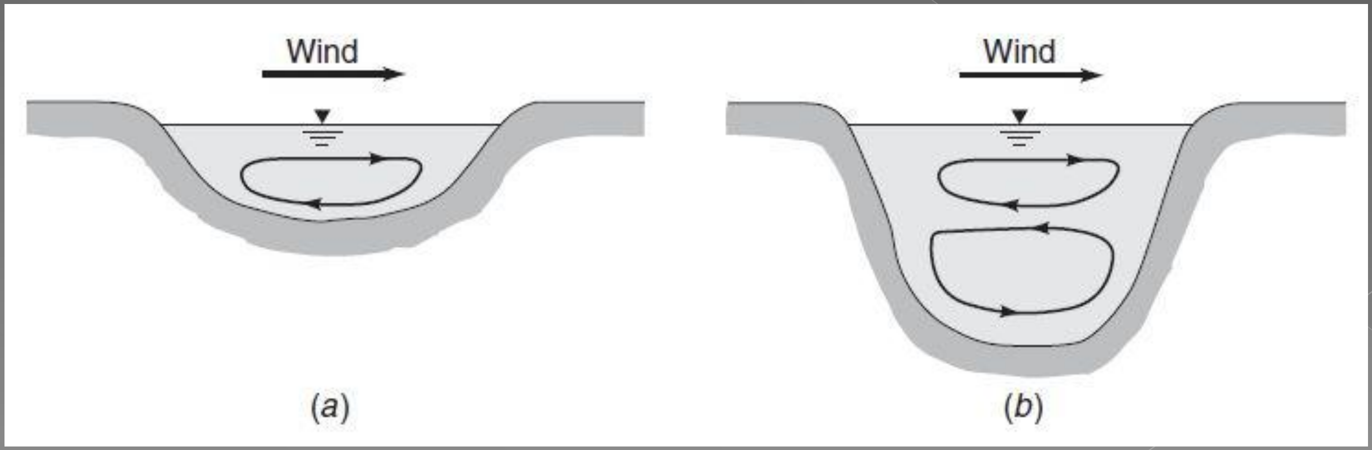
Water movement in lakes influence the distribution of nutrients, microorganisms, and plankton and therefore affects biological productivity and the biota.

Driving Forces

- Wind
- River discharges
- Density
- Coriolis force





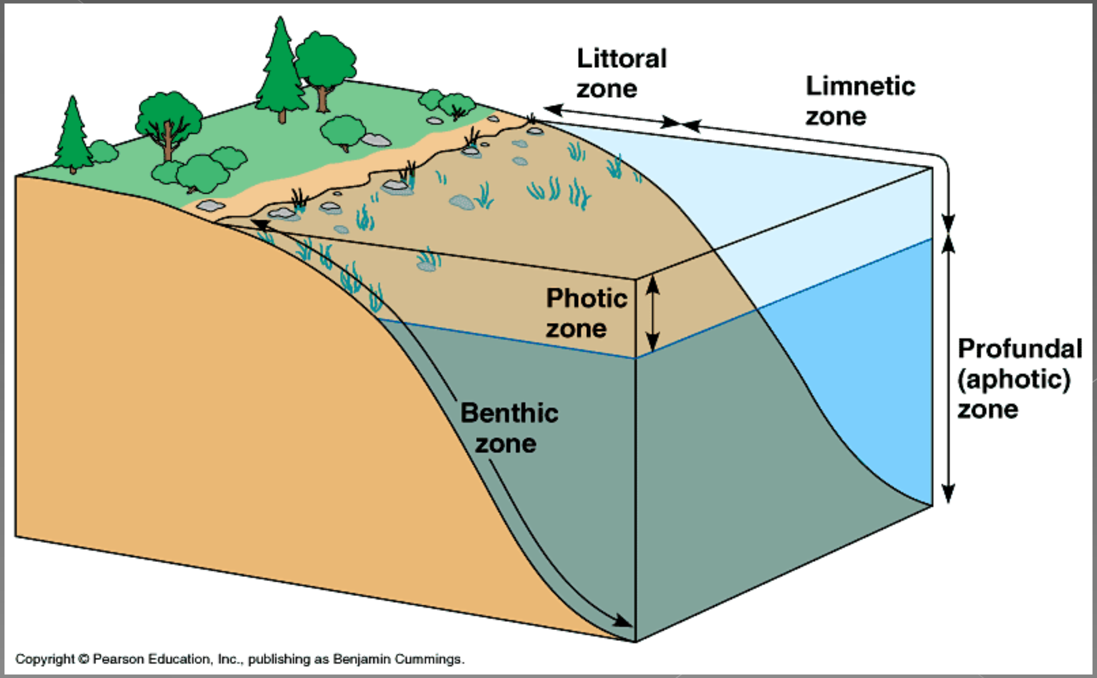


Light penetration

Transmission of light through the water column influences primary productivity (growth of phytoplankton and macrophytes), distribution of organisms, and behavior of fish. Function of scattering and absorption. Directly related to the depth of the euphotic zone.

Controlling factors

- Water surface film
- Suspended particulates
- Turbidity
- Algal/bacterial
- Color

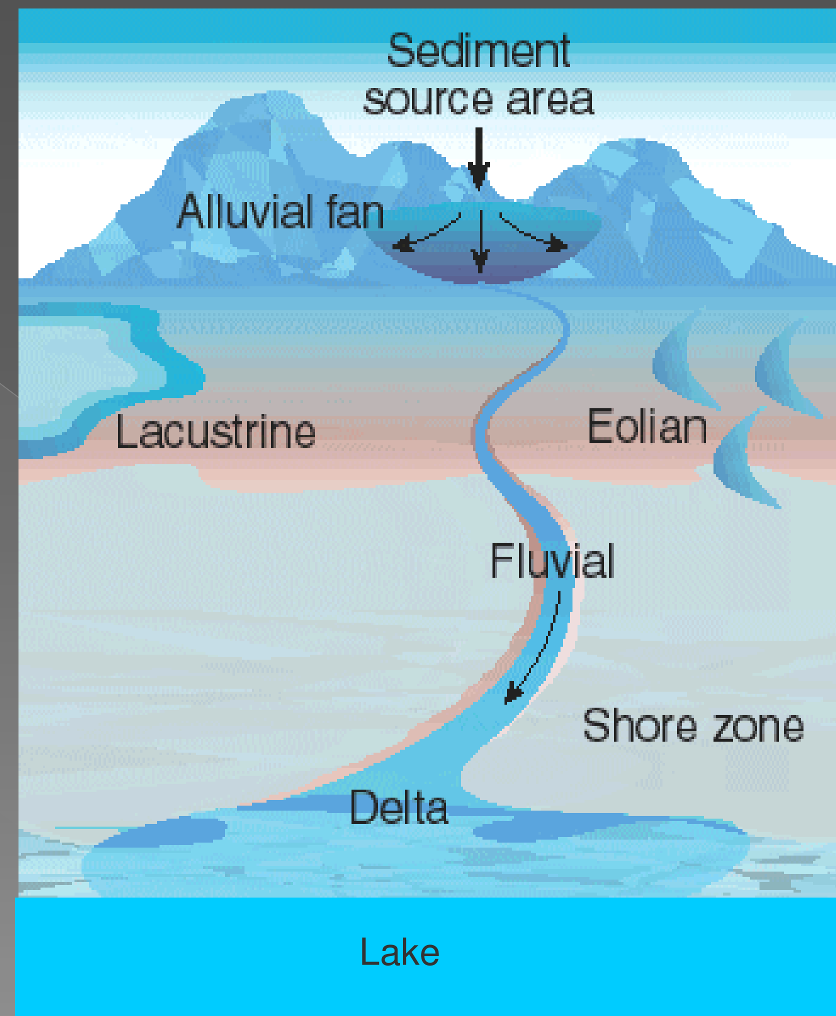


Sedimentation

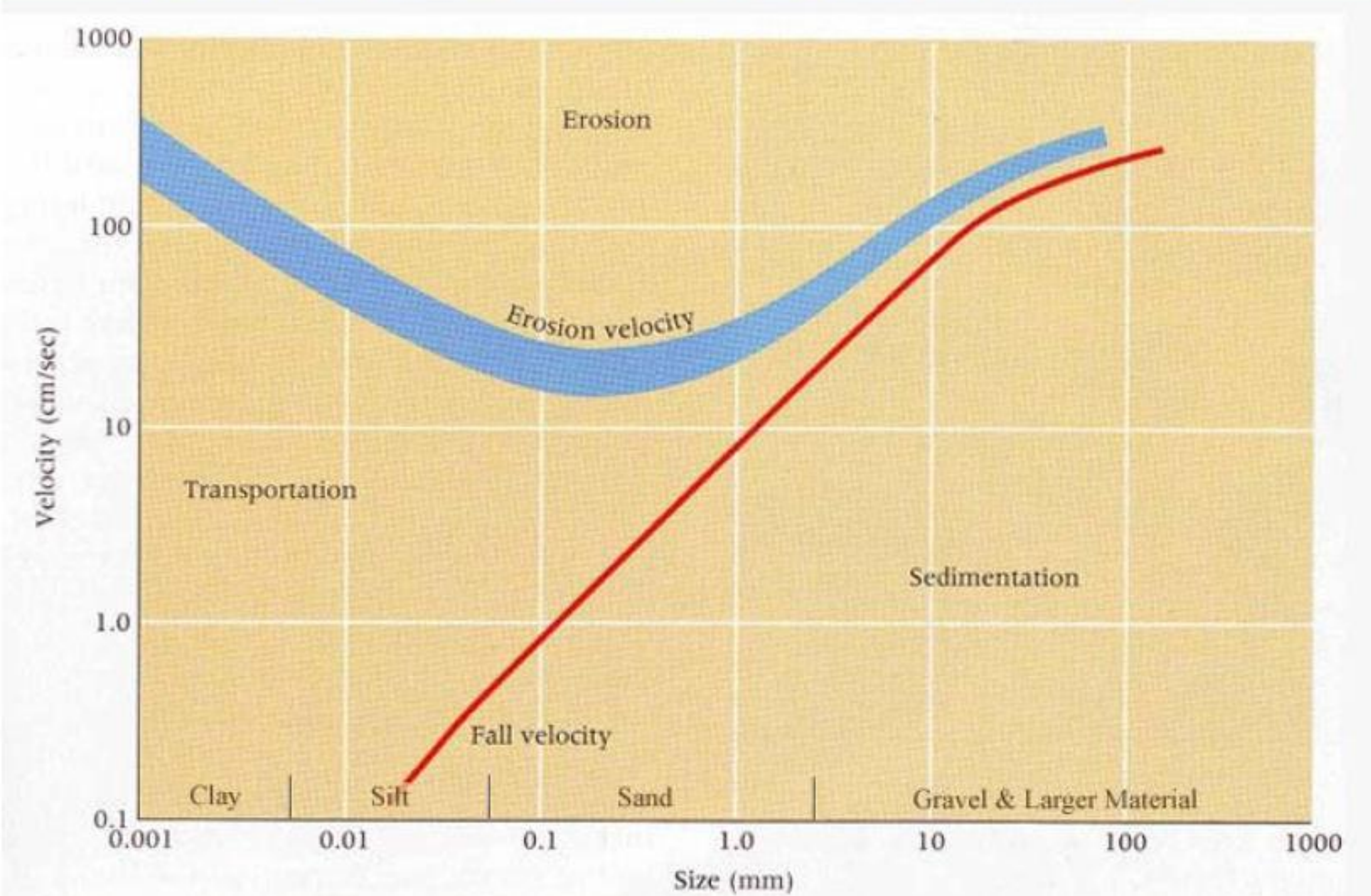
Because of the low water velocities in lakes, sediments transported by inflowing waters tend to settle out.

Sedimentation impacts

- Reduced storage capacity
- Reduced light penetration
- Affects bottom habitat
- Absorbs chemicals and organic matter



Erosion, Transportation and Sedimentation Properties of Various Sediments



Lake/Reservoir Sedimentation

- To derive lake/reservoir sedimentation rates, it is important to consider both specific weight of sediment deposit and volume of sediment input.
- The specific weight of settled sediment vary with age and character of the deposit. The specific weight of dry sediment samples from reservoirs range between 40-90 lb/ft^3 (650-1500 kg/m^3)with an average of about 50 lb/ft^3 (800 kg/m^3) for fresh sediments and 80 lb/ft^3 (1300 kg/m^3) for old sediments.
- Dry specific weight of sediment deposit can be estimated from:

$$W = \frac{\%sand}{100}\left(W_1 + \mathrm{B}_1\log\mathrm{T}\right) + \frac{\%silt}{100}\left(W_2 + \mathrm{B}_2\log\mathrm{T}\right) + \frac{\%clay}{100}\left(W_3 + \mathrm{B}_3\log\mathrm{T}\right)$$

- In which W is the specific weight (dry) of a deposit with an age of T years; W_1, W_2, W_3 represent the specific weights of sand, silt, and clay at the end of first year, and; B_1, B_2, B_3 are constants having the same units as W that relate to the compaction characteristics of the soil types.

TABLE 7.2
Constants in Eq. (7.3) for estimating specific weight of reservoir sediments*

	Sand		Silt		Clay	
Reservoir operation	W_1	B_1	W_2	B_2	W_3	B_3
Sediment always submerged or nearly submerged	93	0	65	5.7	30	16.0
Normally a moderate reservoir drawdown	93	0	74	2.7	46	10.7
Normally considerable reservoir drawdown	93	0	79	1.0	60	6.0
Reservoir normally empty	93	0	82	0.0	78	0.0

* From E. W. Lane and V. A. Koelzer, "Density of Sediments Deposited in Reservoirs of a Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams," U.S. Army Corps of Engineers, St. Paul, Minn., 1953.

Sample Problem:

Estimate the specific weight (dry) of deposited sediment that is always submerged. The sediment is 20% sand, 30% silt, and 50% clay by weight. Calculate the specific weights of the deposited material and the volume occupied by 500 tons (1 ton = 2000 lbs) of sediments after 2 years and 10 years.

Solution:

Substitute all given values to the specific weight equation:

$$W = 0.20(93 + 0) + 0.30(65 + 5.7\log T) + 0.50(30 + 16\log T)$$

Compute specific weight for each year:

For T = 1, W = 53.1 pcf

For T = 2, W = 56.0 pcf

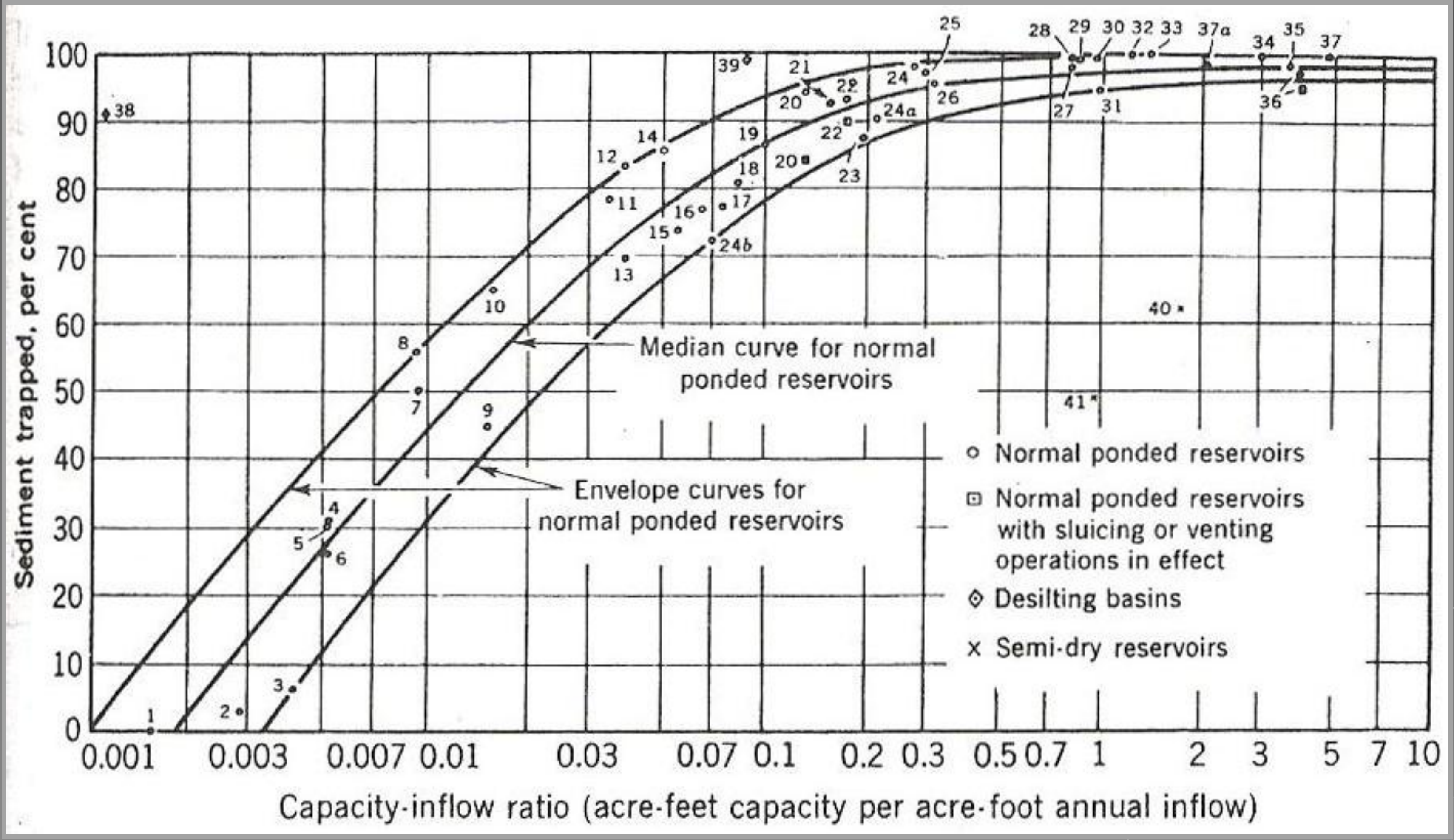
For T = 10, W = 62.8 pcf

Compute for volume:

Volume (2nd year) = $\dfrac{500 \times 2000}{56} = 17,857\, ft^3$

Volume (10th year) = $\dfrac{500 \times 2000}{62.8} = 15,920\, ft^3$

• The percentage of the inflowing sediment that is retained in a lake/reservoir, called the *trap efficiency,* is a function of the ratio of lake/reservoir capacity to total inflow.



- The figure may be utilized to estimate the amount of sediment a lake/reservoir will trap if the average annual sediment load of the stream/s is known. The volume occupied by the sediment can be computed, using a reasonable value of specific weight for the deposited sediment.

Sample Problem:

Using the figure for sediment trapped efficiency, determine the probable life of a small lake with an initial capacity of 30,000 acre-ft if the average annual inflow is 60,000 acre-ft and the average annual sediment inflow is 200,000 tons. Assume a specific weight of 70 pcf for the sediment deposits. Estimate the length of time when 80% of the lake's initial capacity is filled with sediments. Note: 1 ac-ft = 1525 tons of sediments

Solution:

Capacity (ac-ft)	Capacity-inflow ratio	Trap efficiency (%)		Annual Sediment		Increment	Years to fill
		At indicated volume	Average for increment	Tons	ac-ft	ac-ft	
30,000	0.5	96.0					
24,000	0.4	95.5	95.7	191,400	126	6000	48
18,000	0.3	95.0	95.2	190,400	125	6000	48
12,000	0.2	93.0	94.0	188,000	123	6000	49
6,000	0.1	87.0	90.0	180,000	118	6000	51

Eutrophication and nutrient cycling

Excessive production because of excessive nutrient supply.

Eutrophication impacts

- Excessive growth of floating plants
- Excessive fluctuation in O_2 and CO_2 levels
- Excessive SOD
- Loss of diversity