1) Two major aspects of water and wastewater treatment that reflect fundamental physical, chemical, or biological principles are as follows:

a) Aspect: Particle settling in sedimentation tanks used for water treatment.

Fundamental Principle: Physical. Particle settling depends on force balances occurring between gravity, buoyancy, and drag. Drag, a function of the Reynolds Number, is determined from the settling velocity of a particle, the particle's diameter, and the kinematic viscosity of water. If the Reynolds Number is less than one, for example, settling behaves according to Stoke's Law for creeping flow. This law allows that settling velocity is low enough to ignore inertial effects of the fluid on particle settling. In other words, it assumes that the water in which particles are settling is very calm, and drag experienced by the particles is low. If the Reynolds Number is higher, and higher drag forces act upon the settling particles as a result, the settling rate may change. Depending on this settling rate, certain measures may have to be taken to increase the efficiency of particle settling. For example, the dimensions of a reactor tank may have to be altered to allow the most particles to settle by the time the effluent leaves the tank.

b) Aspect: Removal of volatile organic compounds (VOCs), ammonia, and hydrogen sulfide from water by air stripping.

Fundamental Principle: Chemical and physical. The governing principle behind the process of air stripping is Henry's Law, in which the molar concentration of gas divided by the molar concentration of water is equivalent to Henry's Law constant. A dimensionless quantity, this constant is used to determine the rate of mass transfer across the air-water interfaces of thin air or water films running through a stripping tower. As one of the goals of an air stripping tower is to achieve Henry's Law equilibrium, the point at which the air to water ratio with perfect efficiency is at a minimum, certain tower parameters may be altered to ensure the most mass transfer, and thus species removal, is taking place. By changing the interface area between air and water, for example, achievable by changing the cross-sectional area of the tower, it may become possible for more of the offending species to be removed. This is because more influent mass is able to be diffused across the air-water boundary formed from water coming down from the top of the tower as clean air is drafted upwards against it.

2. Effluent quality is predicted by Eq. 30 of Lecture 17:

$$S = \frac{K_s\,(1 + k_d \Theta_c)}{\mu_{max}\Theta_c - k_d\Theta_c - 1}$$

At 20 C:

$$S = \frac{40 \text{ mg COD/L} \;(1 + 0.1 \cdot 5)}{6 \cdot 5 - 0.1 \cdot 5 - 1} = 2.1 \frac{\text{mg COD}}{\text{L}}$$

At 0 C:

$$k_d = k_d(20) \cdot 1.04^{-20} = 0.46\, k_d(20)$$

$$= 0.46 \cdot 0.1 = 0.046 \text{ day}^{-1}$$

$$\mu_{max} = \mu_{max}(20) \cdot 1.07^{-20} = 0.26\, \mu_{max}(20)$$

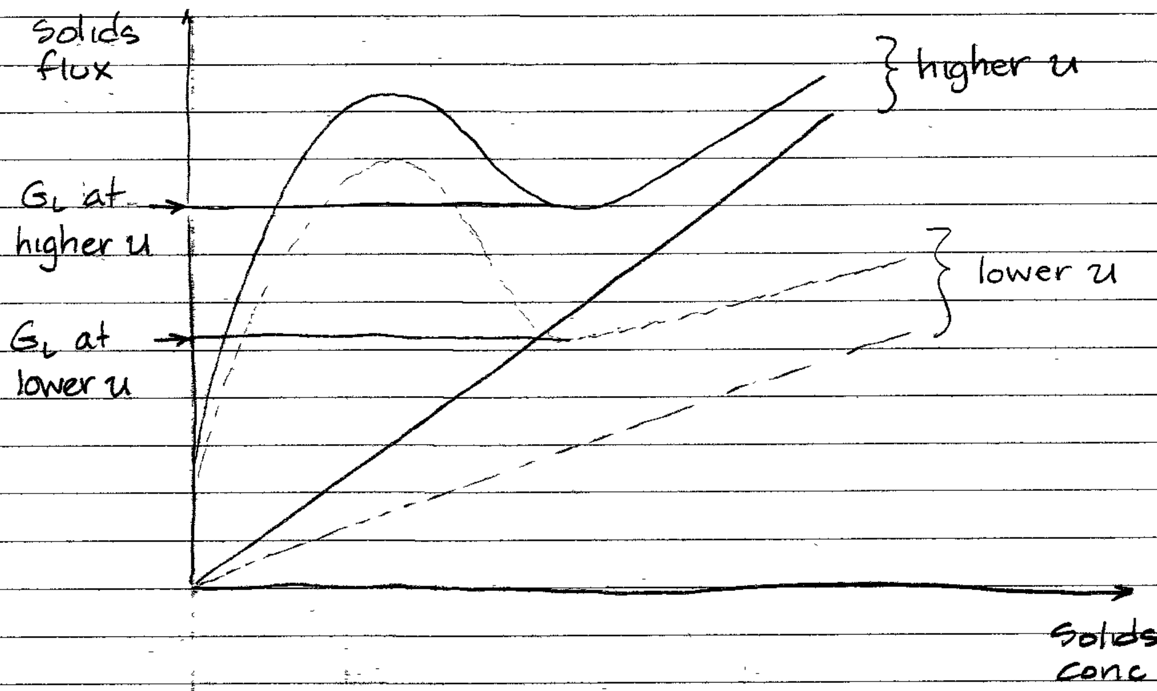
$$= 0.26 \cdot 6 = 1.55 \text{ day}^{-1}$$

$$S = 2.1 \frac{\text{mg COD}}{\text{L}} = \frac{40\;(1 + 0.046\,\Theta_c)}{1.55\,\Theta_c - 0.046\,\Theta_c - 1}$$

$$3.26\,\Theta_c - 0.097\,\Theta_c - 2.1 = 40 + 1.84\,\Theta_c$$

$$\Theta_c = 42.1 / 1.323 = 32 \text{ days}$$

3. a. Increasing sludge withdrawal would increase total solids flux. This is shown by total solids flux curve:



b. Shallow stream is more turbulent and has better mixing of oxygen, which is needed. Also rocks create substrate for biofilm that can support bacteria that mediate nitrification. Muddy bottom does not support biofilm. and mud itself is anaerobic, an environment in which ammonia is not oxidized. Stream itself will be in essentially washout condition for suspended bacteria.

-2 for not pointing out rocks are biofilm medium

c. The wet leaves were anaerobic and the slower degradation process did not have enough time to break down the leaves.

-1 for not pointing out anaerobic is slower than aerobic

d. No. DAF works only on nearly neutrally bouyant solids. The Chattahoochee river sediment would be too dense and heavy. DAF would be a poor choice for most river waters for this reason.

e. Passing high flows could cause a washout of the aeration tank, and wipe out the bacterial culture that treats the water. It could also cause the sludge blanket in the secondary clarifier to get too thick and overflow the clarifier.

f. The increase in fees for water dramatically reduced usage - people finally repaired leaky fixtures and became careful about water use. Wastewater flows decreased (although BOD/COD increased) and wastewater plants were no longer overloaded.

4. a. The first two steps – aerobic followed by anoxic – mimicks postanoxic denitrification (see Lecture 19, pg 4), however the anoxic step generally requires supplemental electron donor addition (e.g. methanol). The nitrate recycle supplies an electron acceptor (nitrate) but not enough electron donor to contribute to denitrification in the anoxic step.

Subsequent steps 3 and 4 (aerobic followed by anoxic) will occur under substrate-starved conditions and achieve little additional benefit – some minor nitrification and denitrification and minor substrate degradation

The anerobic tank at the end makes no sense at all. Anaerobic conditions are created to act as a "selector" for PAOs, which are then available to consume ortho-P in the subsequent anoxic or aerobic step. All the anaerobic tank will do is interfere with the secondary clarifier by creating odors

Summary: system will remove BOD, some N, not much P

Scoring for 4a

6 pts - identifying problem with anaerobic tank location and fact P will not be removed

2 pts - identifying BOD removal will occur

2 pts - identifying N removal will occur

2 pt - extra credit for indicating flaws in electron donors / acceptors for N removal

4 b. The anaerobic tank is hopeless, but the performance of the first anoxic tank could be improved by feeding some of the wastewater into that tank directly to provide electron donors for denitrification. (or could feed methanol)

Another possibility is to recycle flow from anaerobic tank back to first anoxic tank to get PAO's working on influent wastewater.

Could also treat sludge as in PhoStrip process to remove P.