FINAL EXAM

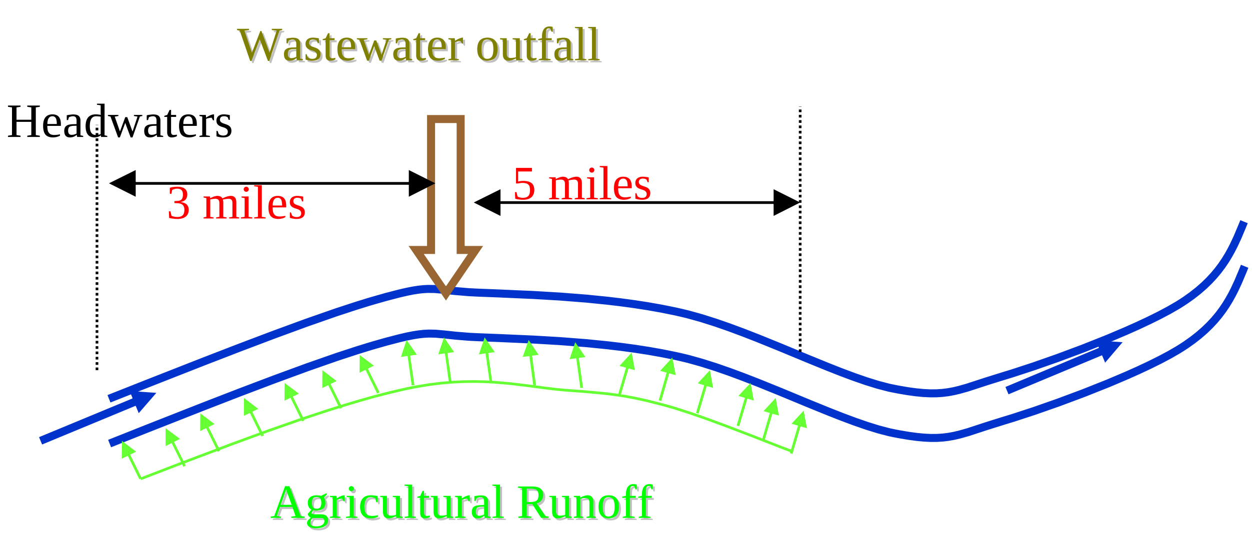
Closed book, 2 sheets of notes allowed.
Answer question #1 and one of the remaining 2 questions. Please state any additional assumptions you made, and show all work.

1. (70%) River Problem (answer this problem)

Ruminant River emerges from pristine headwaters and runs through an agricultural region before it reaches the city of Vacheville. The BOD of the headwaters is 6 mg/L, and the dissolved oxygen is 8.2 mg/L (saturation is 10.1 mg/L for 15^oC). Starting at mile point zero, there is a significant non-point agricultural runoff of BOD amounting to 45 kg/mile/day. At mile point 3.0, the stream is met by the Vacheville WWTP outfall. Here a WW flow of 2 cfs is discharged with a CBOD of 100 mg/L, an ammonia-N concentration of 14 mg-N/L and a DO of 6 mg/L. Immediately past this outfall is 5 more miles of agricultural land. This is better managed than the upstream land, so that the runoff BOD averages 25 kg/mile/day. **Calculate the dissolved oxygen concentration 5 miles downstream of the Vacheville WWTP outfall** (T=15^oC). Assume the flow is constant at 40 cfs from the headwaters to the end of the non-point agricultural runoff. You may also assume an SOD downstream of the WWTP outfall of 1.5 g/m^2/d.

Additional Information:

U = 0.150 ft/sec = 2.45 miles/day	T = 15^oC
DO_{sat} or C_s = 10.1 mg/L (at 15^oC)	H = 4 ft = 1.22 m
BOD deoxygenation rate ($k_N = k_d$) = 0.8 day^{-1} (at 15^oC)	for k_N and k_d, θ=1.047
CBOD settling rate (k_s) = 0.080 day^{-1} (at 15^oC)	for reareation, θ=1.024



2. (30%) Toxics Problem (answer either this problem or #3)

Lake Lackluster is situated in a pristine watershed. Although there are no known point sources of Methyl t-Butyl Ether (MtBE), the lake does receive a substantial loading from rainfall. Using the information below, calculate the following:

A. Fraction adsorbed in the water column
B. Velocity of volatilization

Assume the lake is at a temperature of 25°C. (universal gas constant, $R=8.206\times10^{-5}$ atm m^3/°K mole).

Characteristics of Lake Lackluster

Characteristic	Value
Volume	3,000,000 m^3
Average Outflow	20,000 m^3/day
Mean Depth	3 m
Mean Wind Speed	0.5 m/sec
Solids Settling Rate	0.2 m/d
Solids Burial Rate	0.000007 m/d
Sediment:Water Diffusive Exchange Rate	0.001 m/d
Water Column Suspended Solids	2.2 mg/L
Mixed Sediments Suspended Solids	12,000 mg/L
Thickness of Mixed Sediments	0.2 meters
Fraction of Organic Carbon in Solids	0.2
Density of Suspended Solids	1.55 g/mL
Drainage area	2300 ha

Selected Physical and Chemical Properties of MtBE

Property	**Value**	**Special Conditions**	**Reference**
Molecular Weight	88.15		
Melting Point	-109°C		Weast, 2000
Boiling Point	55.2°C		Weast, 2000
Density	0.7405 g/mL	20°C	Weast, 2000
Aqueous Solubility	4-5%	20°C	Gilbert & Calabrese, 1992
Log K_{ow}	1.05		Gilbert & Calabrese, 1992
Vapor Pressure	$2.45\times10^{+2}$ mm Hg	20°C	Merck, 2000
Henry's Law Constant	5.87×10^{-4} atm-m^3/mol		HSDB, 1994
Log K_{oc}	2.7		Davidson et al., 1980
Diffusivity in Water	4×10^{-6} cm^2/s		Estimated
Biodegradation Rate	0.001 d^{-1}	dissolved	Estimated
Photolysis Rate	0.0041 d^{-1}		Estimated
Hydrolysis Rate	0.0071 d^{-1}	25°C, neutral only	Estimated

The following relationship between the liquid film mass transfer coefficent (K_l) and the wind speed (U_w) and toxicant diffusivity in water (D_l) may prove useful.

$$K_l \approx 0.0017 D_l U_w$$

3. (30%). Short Answer (answer either this problem or #2)

On a separate sheet of paper, answer any five (5) of the following questions

A. Describe and contrast two different algal growth models.

B. Explain the benefits of conducting a dye study on a river as compared to the use of a mechanical (e.g., Pygmy) flow meter

C. What are the different sources and sinks of heat energy in a surface water?

D. Describe 3 general approaches taken for modeling sorption of toxics to particles in surface waters

E. Describe the various steps involved in photolysis of toxics in surface waters. Include some discussion on how these steps are modeled.

F. Discuss the ultimate fate of PCBs in the Great Lakes. Where do they end up, and why?

G. Describe how you would estimate the bulk vertical mixing coefficient in a stratified lake.

H. Why does the Streeter-Phelps equations sometimes predict negative concentrations of dissolved oxygen, despite the fact that this is physically impossible? How can one correct this problem?