1.85 WATER AND WASTEWATER TREATMENT ENGINEERING
TAKE-HOME MID-TERM EXAM
DUE TUESDAY APRIL 5, 2005 AT 1:00 PM

This is an open-book exam, with the exception that you are asked to restrict your use of Internet sources to the links included on the 1.85 course webpage and to routine information sources like unit conversions. Unlike the homework, collaboration is not permitted—please do not work with others on this exam.

1. A surface water with the water-quality characteristics listed below is being considered for a municipal water supply.
   a. Which water-quality constituents are problematic and why (short answer)? (10 points)
   b. Identify a set of treatment technologies (unit processes) to make this water suitable for drinking water. (10 points)

Turbidity	170 NTU
Iron	13.0 mg/L
Calcium	50.8 mg/L
Magnesium	0.9 mg/L
Sodium	6.9 mg/L
Potassium	0.4 mg/L
Taste & odor	Unacceptable in summer

Manganese	1.0 mg/L
Carbonate	0 mg/L
Bicarbonate	116 mg/L
Sulfate	31.0 mg/L
Chloride	10.8 mg/L
Nitrate	1.9 mg/L as NO_3

2. A ground water with the water-quality characteristics listed below is being considered for a municipal water supply.
   a. Which water-quality constituents are problematic and why (<u>short</u> answer)? (10 points)
   b. Identify a set of treatment technologies (unit processes) to make this water suitable for drinking water. (10 points)

Turbidity	0.1 NTU
Iron	0.2 mg/L
Calcium	121 mg/L
Magnesium	57 mg/L
Sodium	117 mg/L
Potassium	3 mg/L

Manganese	0.04 mg/L
Carbonate	0 mg/L
Bicarbonate	298 mg/L
Sulfate	240 mg/L
Chloride	210 mg/L
Nitrate	7.4 mg/L as NO_3

3. You are the environmental manager for the Big Dig. The Massachusetts Department of Environmental Protection is requiring that 85% of all suspended solids be removed from any water pumped on the project. You have to come up with an inexpensive, on-site treatment system to achieve this.

a. Assume that the suspended solids in the pumped water are a typical silt particle with an equivalent diameter of 62 microns and density of 2.6 g/cm^3. Assume a kinematic viscosity of 0.01 cm^2/sec. What is the settling velocity of a particle assuming discrete particle settling and creeping flow? Is the creeping flow assumption valid? (10 points)

b. You would like to adapt a "roll-off box" as a sediment settling tank. A typical "roll-off" box is rectangular, 2.5 m wide by 4 m long by 1.5 m high. You plan to pump the water into one end of the tank such that it is uniformly distributed across the width and depth of the tank. Similarly, at the other end of the tank, water will be drawn uniformly from the full width and depth of the tank (see sketch). Assume the sediment settles at a constant velocity and that any sediment that settles to the bottom of the tank sticks to the bottom and is removed. You can ignore diffusion as a transport process. How much flow can you pass through the box and still achieve 85% removal? (10 points)

c. You implement your roll-off-box treatment unit and it works pretty well, except you are encountering more clay particles than anticipated. Because the clay particles are smaller, they do not settle as well as the silt particles you assumed in your design. You already have the roll-off boxes bought and on-site and are stuck with them. Describe briefly how you could improve settling in the roll-off boxes. (5 points)

4. A shallow pond receives organic wastes from a fruit juice processing factory. The pond has operated successfully under the following conditions. The pond volume is 3.5×10^5 m^3; the wastewater flow rate into the pond is 0.2 m^3/s; and the average concentration of organic matter in the waste measured as COD is 300 mg/L. The long-term average pond effluent into an adjacent river has a concentration of 50 mg/L of COD. The pond may be assumed to be fully mixed and the COD removal may be assumed to be first-order.

   a. Calculate the rate constant for COD removal in the pond. (5 points)

   b. The EPA has set new discharge permit conditions that will require the pond effluent COD to be 35 mg/L. Two options are being considered:

      i. Modify internal operations to produce a plant waste stream having the same flow rate as before but with a COD concentration of 200 mg/L.

      ii. Retain the original waste stream concentration and flow rate but mix the plant discharge with fresh water to reduce the waste concentration to 200 mg/L as it enters the pond. (Ignore for purposes of this problem that this approach is not allowed by EPA rules.)

      Which option to do you recommend? Demonstrate through calculations why it is preferred. (10 points)

   c. Describe an alternative option for reducing the pond effluent concentration and demonstrate with calculations why it would work. (10 points)

5. WATER QUALITY MIX AND MATCH

Match the water-quality constituents in Column 1 with the corresponding effect in Column 2 by filling in the corresponding letter as shown by the example. Be careful!—some of the effects in Column 2 could be used for multiple constituents in Column 1. You should pick the effect that best fits each constituent. There is a one-to-one correspondence between the columns (i.e., you should use each effect from Column 2 for only one constituent in Column 1). (1 points each, 10 points total)

Column 1 — Water-quality constituent

	Water-quality constituent	**Fill in**
Ex.	**Selenium**	**c.**
1.	Nitrate	
2.	Trihalomethanes	
3.	Fluoride	
4.	Giardia	
5.	Un-ionized ammonia	
6.	*Pseudomonas aeruginosa*	
7.	Phenols	
8.	Hardness	
9.	*Schistosoma*	
10.	Manganese	

Column 2 — Effect

	Effect
a.	Suspected to cause cancer
b.	Dermatitis
c.	Hair loss
d.	Snail fever
e.	Blue-baby syndrome
f.	Scaling of pipes and boilers
g.	Taste and odor
h.	Toxicity to fish
i.	Staining of laundry and bathroom fixtures
j.	Staining of teeth
k.	Gastrointestinal illness