ENGS-43, Winter 2012
ENVIRONMENTAL TRANSPORT & FATE

HOMEWORK #2

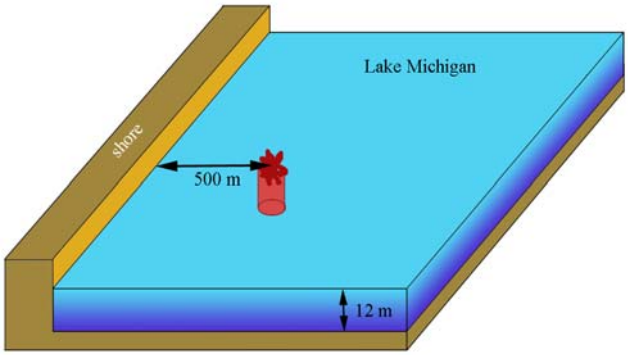
Assigned: Friday 13 January 2012
Due: 11:15am, Friday 20 January 2012

1. (10 points) In an infinitely long one-dimensional system, two instantaneous releases of equal magnitude M occur at the same time (say $t = 0$) and at a distance L apart from each other (say $x = 0$ and $x = L$). What is the maximum concentration value reached over time at the middle point (at $x = L/2$)?

2. (10 points) A small boat crosses Lake Bled to reach the center island where it intends to deliver a load of wood stain to restore some wood panels inside the small church there (see photo below). But, on its way, it accidentally spills 10 kg of this product over an area of 5 m^2, at a location where the depth is 9 m. Assuming that the wood stain mixes well with water and taking the vertical diffusivity equal to 0.015 m^2/s, determine the concentration of wood stain at mid-depth and at the bottom at selected times. Does the mid-depth value reach a maximum before reaching its ultimate value? Also, what is this ultimate value? Finally, by which time would you say the wood stain is well mixed over the vertical?

(*Two more questions on second page*)

3. (10 points) In Lake Michigan, a barge accidentally spilled 350 kg of a conservative contaminant 500 m from shore and within a brief amount of time. Assuming rapid mixing in the vertical, a uniform depth of 12 m in the area, a straight coastline and a horizontal diffusivity of 3.0 m^2/s, trace over time the concentration of the contaminant at the location of the spill and at the nearest point along the shore. Discuss your findings.



4. (10 points) Partially treated sewage with a BOD of 48 mg/L is continuously discharged at the rate of 3.0 m^3/s at the bottom of a 5-m lake by means of a pipe lying on the bottom and extending 100 m away from the shore, as depicted below. In that region, the lake waters move uniformly in the alongshore direction with a speed of 0.08 m/s. Once in the water, the sewage decays at the rate K = 0.24 /day and diffuses at the rate D = 3.0 m^2/s.

Assuming that the discharge does not significantly alter the water flow (no jet), that vertical mixing takes place almost instantaneously (thanks to the buoyancy of the sewage, which is slightly warmer than the lake water) and that the situation is highly advective (high Peclet number), determine the 2D horizontal distribution of sewage concentration.

If you had to write a piece for a local newspaper describing the effect that this sewage is having on the water near the shore, what would you say?