Date distributed : 2.6.2012  
Date due : 2.16.2012 at 1:50 p.m.  

Return your solution either in class or in my mail box (8th Floor, CE/TTI) by the date shown above. Please show all your work and follow the rules outlined in the course syllabus. Undergraduate-only problems are designated with a leading (U), and graduate-only problems are designated with a leading (G). If no designation is given, the problem should be worked by both graduate and undergraduate students.

1 Homework and Book Catalog

Work problems 3.1, 3.3, and 3.7 in the Homework Catalog on the Assignments page of the course webpage. Graduate students (G) also work problem 3.10.

Work problem 3.2 in the Chin textbook Water Quality Engineering in Natural Systems. Graduate students (G) also work problem 3.3.

2 Image Source Solutions

Approximate a marina as a rectangular box of length 400 m and width 100 m with uniform depth of 4 m. Wind and waves work to keep the marina well-mixed so that the longitudinal diffusion coefficient (along the length of the marina) is 5 m$^2$/s and the lateral diffusion coefficient (along with width) is 2 m$^2$/s; the effective vertical diffusion coefficient is 1.5 m$^2$/s.

A spill occurs in the middle of the marina at the surface of the water. Determine the following:

a. How long after the spill may the spill be considered well-mixed in the vertical? After this time, the spill may be considered as a two-dimensional point source in the plan-view of the marina.

b. When does the spill cloud grow large enough that the sides of the marina must be taken into account in the solution? I.e., when do you need to include image sources to obtain a reliable solution?

c. Draw a sketch of the marina and show the locations of the necessary image sources to account for two-dimensional mixing of the point source in the marina. Write down the summation solution for concentration based on these image sources.
d. When can the spill be considered well-mixed throughout the marina? Based on this calculation, how accurate is it to use the CSTR solutions for marina design applied to this marina?

3 Spill Analysis

A railroad accident results in the instantaneous release of 500 kg of organic nitrogen fertilizer into the Brazos River (flow rate $Q = 120 \text{ m}^3/\text{s}$ and cross-sectional area $A = 520 \text{ m}^2$) at the edge of the river. Use simple characteristic scales of the problem to answer the following key questions. Let the diffusion coefficients be $5 \text{ m}^2/\text{s}$ in the longitudinal, $0.2 \text{ m}^2/\text{s}$ in the lateral, and $0.003 \text{ m}^2/\text{s}$ in the vertical directions, respectively.

a. How far downstream is the release well-mixed in the vertical?

b. How far downstream does the spill first touch the opposite stream bank? When does this occur? What is the maximum concentration in the river?

c. How far downstream can the spill be considered well-mixed in the lateral direction?

d. An irrigation intake is 25 km downstream on the same side of the river as the spill. What is the maximum concentration at the intake? When does it occur? For how long is the intake affected by the spill?