

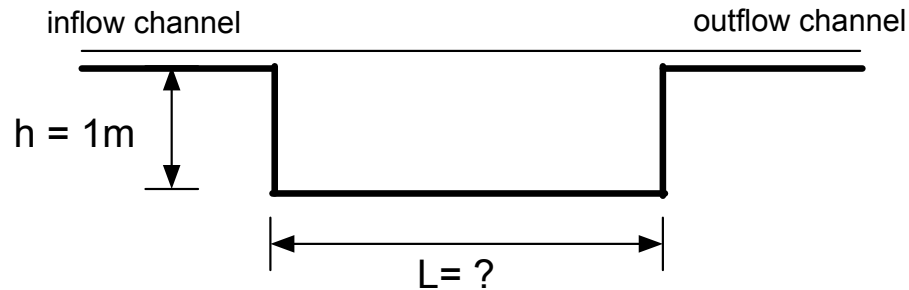
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1.061 / 1.61 Transport Processes in the Environment  
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**Problem 10.1**

You are an environmental manager for a major construction site. The local regulatory authority requires that 85% of all suspended solids be removed from any water that is released off site. To remove the suspended solids you plan to pass the water through a settling tank. Assume that the majority of the suspended solids are silt with a mean diameter  $d = 62$  micron and density  $\rho_p = 2.6\text{gcm}^{-3}$ . During typical operations you need to treat  $100\text{ m}^3$  of water per hour, or approximately  $Q = 0.03\text{ m}^3\text{s}^{-1}$ . The available area for digging the settling pond is  $2\text{ m}$  wide and can be  $1\text{ m}$  deep. How long should the pond be?

**Problem 10.2**

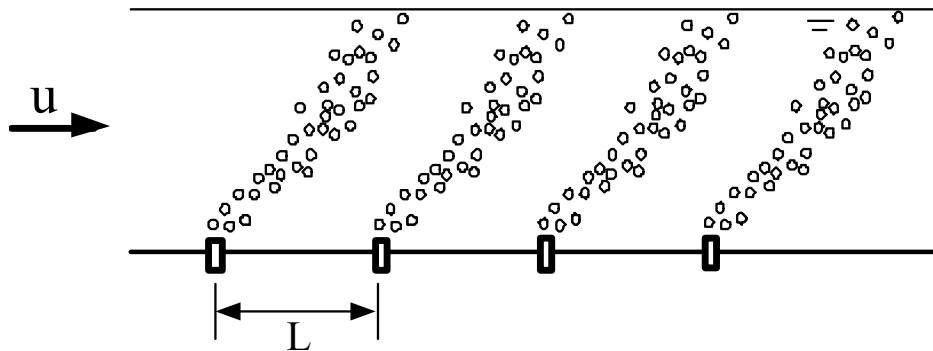
Consider a  $20\text{-cm}$ -deep water channel with a mean flow of  $0.1\text{ cm/s}$ . The flow conditions are laminar.  $N$  particles are released instantaneously from a point source located  $h = 5\text{ cm}$  above the bed. The particles are spherical with diameter  $d = 10\text{ }\mu\text{m}$  and density  $\rho_p = 2000\text{ kgm}^{-3}$ . Describe the downstream position and length of the particle patch left on the bed after all particles have settled. For particles of this size, the particle diffusion rate is  $10^{-13}\text{ m}^2\text{s}^{-1}$ .

### Problem 10.3

A tree releases its seeds once per year from pods located at  $H = 10\text{m}$  above the ground. At this height, the horizontal extent of branches is  $4\text{m}^2$ . The opening of the pods is triggered by a shift in air temperature, and once triggered all seeds are released within five seconds. The seeds are spherical with diameter  $d = 50\ \mu\text{m}$  and have density  $\rho_s = 600\ \text{kgm}^{-3}$ . During the release a wind is blowing at  $U = 2\ \text{m/s}$ , which you may assume is constant over height. Assume the constant, uniform, turbulent diffusivities in the vertical ( $D_z = 0.1\ \text{m}^2\text{s}^{-1}$ ) and horizontal ( $D_x = D_y = 1\ \text{m}^2\text{s}^{-1}$ ). The air density is  $\rho_a = 1.2\ \text{kgm}^{-3}$ , and absolute viscosity is  $\mu_a = 1.8 \times 10^{-5}\ \text{N s m}^{-2}$ . Assuming that a total of  $N$  seeds are released, write an expression for the seed concentration (seeds  $\text{m}^{-3}$ ) in the air after the release. Describe the longitudinal extent of the seeds on the ground.

### Problem 10.4

A processing plant wants to use bubbles to maintain high mixing conditions in a water channel. Maximum efficiency is achieved when the spacing between individual bubble injectors,  $L$ , is chosen such that new bubbles enter at the bed just as the bubbles from the previous upstream injector are exiting the surface. Determine the spacing,  $L$ , if the mean channel velocity is  $u = 1\ \text{ms}^{-1}$ , the water depth  $h = 1\ \text{m}$  and the average bubble diameter is  $D = 1\ \text{mm}$ .



### Problem 10.5

You have been monitoring the levels of particulate phosphorus in a small lake. Some of your recent measurements are given below. Predict whether the concentrations in the epilimnion will increase, decrease, or stay the same in the near future. The base of the epilimnion is set at the depth of the thermocline, as shown.

Particle settling velocity:  $w_p = 2.0 \times 10^{-6} \text{ m/s}$

Vertical Diffusivity:  $D_t = 2.0 \times 10^{-6} \text{ m}^2/\text{s}$

River Inflow:  $Q_I = 0.1 \text{ m}^3/\text{s}$  with phosphorus concentration,  $C_I = 100 \mu\text{g/L}$

River Outflow:  $Q_O = 0.1 \text{ m}^3/\text{s}$  with phosphorus concentration,  $C_O = 50 \mu\text{g/L}$

Surface Area of Lake:  $2 \times 10^4 \text{ m}^2$

