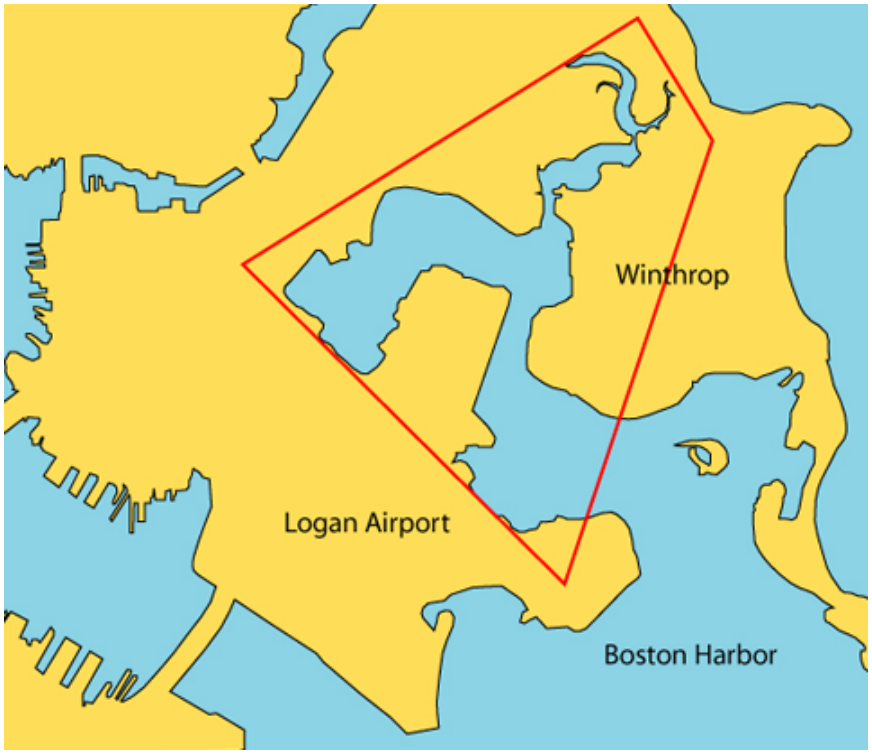
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Civil and Environmental Engineering
1.77 Water Quality Control
Spring 2006

Quiz 2 Open Book and Notes Due May 5, 11am

Problem 1

Ethylene glycol (CH_2OH-CH_2OH) is used for de-icing at Logan Airport and some of it runs off into Boston Harbor. Treat the portion of the harbor indicated below as a well-mixed water body for which the surface area is 2 km^2 and the mean depth at low tide is 8 m. Tides are principally semi-diurnal with a range of 3 m. Using the tidal prism approximation with a 50% return factor, estimate the residence time of material discharged into this portion of the harbor. During a winter storm, a total of 10^4 kg of ethylene glycol runs off quasi-instantaneously into this portion of the harbor at low tide. The ethylene glycol is oxidized to CO_2 and H_2O causing a decrease in the harbor dissolved oxygen concentration. Write the chemical reaction and, assuming that all of the ethylene glycol is oxidized, and that the oxidation takes place instantaneously, what is the maximum decrease in harbor DO concentration (expressed as mg/L)? Assuming a wind speed of 5 m/s, that the oxygen levels throughout the harbor were saturated before the storm, and that there are no other sources/sinks of DO other than re-aeration, estimate the oxygen deficit after one day.



Problem 2

Loihi is an underwater volcano located 1000 m below the surface off the southern coast of the big island of Hawaii. (It is destined to become the next Hawaiian island, and I can recommend a realtor for anyone who would like to speculate.) When it is active, it vents warm geothermal fluid (containing a host of contaminants such as H_2S) that forms a buoyant plume. Measurements within the initial portion of the plume suggest a plume flow rate of about 0.3 m^3/s, a temperature of 30^oC, and salinity which is near ambient. The ambient seawater is density stratified due to a vertical gradient in temperature as depicted in the following table. (Assume salinity is a constant 35 parts-per-thousand.) Does the plume from Loihi reach the surface? If not, at what elevation does it become trapped? Estimate the dilution by the time the plume either reaches the surface or the trap height? You may assume that the discharge is distributed over a sufficiently wide area that initial momentum effects are negligible.

Depth below surface (m)	Temperature (^oC)
0	25
100	21
200	17
300	12
400	8
500	6.4
600	5.7
700	5.2
800	4.8
900	4.4
1000	4.1