CE102: Environmental Studies

Problem Set I: *Environmental Systems*

Q.1 Water Balance – Lakes-Rivers System: An environmental system comprising of two lakes with six rivers is shown in **Figure 1**. The inflows and outflows are shown in the figure. Calculate flow through the rivers B and E. Make suitable assumptions, where needed and clearly mention them.

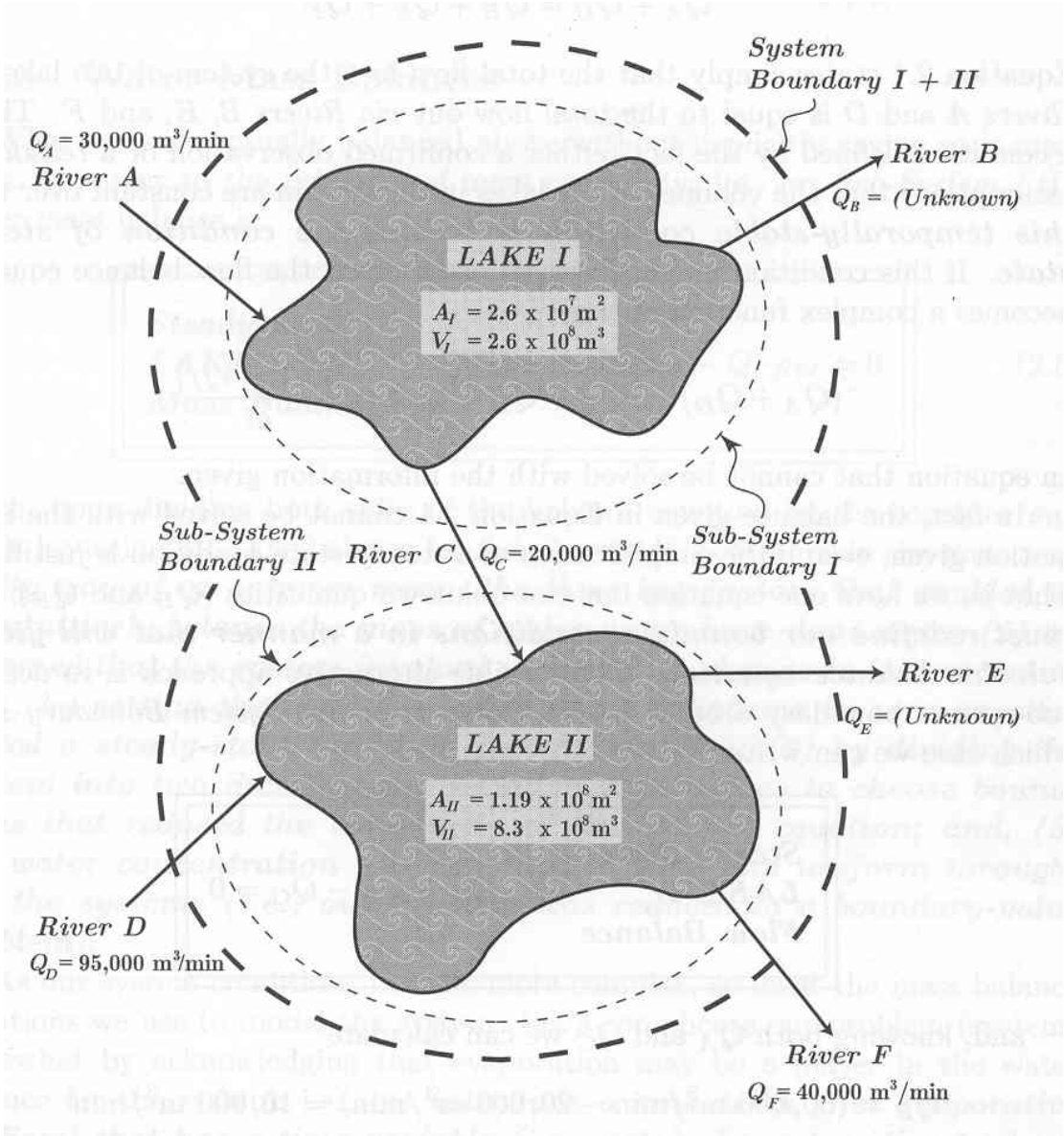

Figure 1: Natural Environmental System: Lakes-Rivers System

Q.2 Water Balance with Evaporation as Sink – Lakes-Rivers System: Considering the entire lake system given in **Q.1**, there was loss of water from the system due to evaporation at a rate of 1.5 cm/day. Calculate flow through the rivers B and E. Make suitable assumptions, where needed and clearly mention them.

Q.3 Constituent (Chloride) Mass Balance – Lakes-Rivers System: Considering the entire lake system given in **Q.2** (Lakes-Rivers System with Evaporation as Sink), a community located along River F just downstream from Lake II uses this river as its source for public water supply. If the chloride (Cl^-) concentration in River A and D are 50 and 100 mg/L respectively, determine the chloride (Cl^-) concentration in River F. Make suitable assumptions, where needed and clearly mention them.

Q.4 Constituent (Lead) Mass Balance – Lakes-Rivers System: Consider for the scenario described below the potential contamination by lead of a raw drinking water drawn from one of the rivers in the lake system presented schematically in **Figure 1** in **Q.1** (Lakes-Rivers System *without* Evaporation as Sink).

A large underground clay-lined waste pit at a former industrial site is located alongside *River A,* near its confluence with LAKE I. The existence of this pit has been known for sometimes, but no seepage has ever been found. After a recent Richter-scale three earth tremor, however, a waste plume from the pit has been discovered, the major contaminant in the stream being lead (Pb^{+2}). Following the onset of the relatively steady new seepage from the pit, dissolved Pb^{2+} concentration averaging 100 μmol/L are found in *River* A immediately above its discharge to *LAKE I*. A community located along *River F* just downstream from *LAKE II* draws its public water supply from that river. The community has a relatively simple water treatment plant that has no provision for removal of dissolved Pb^{+2}. The drinking water standard for lead is 0.05 mg/L. Determine whether the water supply to the community will exceed this standard if there is no remediation of the pit seepage.

The Pb^{2+} undergoes a precipitation reaction of the form:

$$Pb^{2+} + 2OH^- \leftrightarrow Pb(OH)_2(s) \downarrow$$

At a rate given by $r = k\,[Pb^{2+}]\,[OH^-]^2$, where $k = 5.0 \times 10^7$ $(L/mol)^2$ (min^{-1}). The lakes are well buffered at pH = 8.3.

Q.5 Water and Constituent (Chloride) Mass Balance - Lake-Rivers System: The sole sources of water and chloride (Cl^-) to a lake are three rivers: A, B and C. The flow rate of water in *River A* is 1.20 m^3/min and in *River B* is 2.20 m^3/min. *River C* flows into the lake, but the flow rate is unknown. The flow out of the lake is by *River D* only. The concentration of chloride in *River A* is 50 mg/L. The chloride concentrations in *River B* and C are the same. The concentration of chloride in the lake is 75 mg/L. If the detention time in the lake is 2.5 years and the volume is 9.60×10^6 m^3. Find the following:

(a) The flow rate of *River C* in m^3/min;
(b) The concentration of chloride in *River C* in mg/L.