Chapter 4-1
Water Cycle of Lake Biwa

Abstract
Lake Biwa increases its volume by rainfall, river inflow and groundwater infiltration, and decreases it through lake surface evaporation, uptake and outflow. This results in the replacement of 6 billion m^3 of water every year, keeping its volume at about 27.5 billion m^3. A total of 300 million m^3 of intake water is pumped into the upstream reaches and utilized for domestic, industrial and agriculture water supply. These indicate Lake Biwa is a very important water source not only for the downstream area but also for the catchment areas.
Keywords: Water cycle, River inflow, Water supply, Outflow

1. Preface
Every component in water is transported with water, so that it is important to understand water movement in order to gain insight into the behavior of any component. When estimating input loads to Lake Biwa, it is important to study the water cycle of the lake's wider catchment.

2. Water Cycle with the Environs of Lake Biwa
Water levels in Lake Biwa rise due to direct rainfall on the lake's surface, inflow from rivers in the catchment, and groundwater infiltration. Water leaves the lake system through evaporation, outflow, and water intake from the lake. The input and output of the Lake Biwa system can be expressed by the following equation:

$$\text{(lake surface area)} \times \text{(water level change)} = \left(\begin{array}{c}\text{lake}\\ \text{surface}\\ \text{area}\end{array}\right) \times \{\text{(rainfall)} - \text{(evaporation)}\} + \left(\begin{array}{c}\text{river}\\ \text{inflow}\end{array}\right) + \left(\begin{array}{c}\text{groundwater}\\ \text{infiltration}\end{array}\right) - \text{(outflow)} - \text{(intake)}$$

The amount of rainfall, lake water levels, intake flow rates, and outflow rates from the Seta River, Uji Power Station Canal, and Lake Biwa Canal, are continually monitored. Evaporation from the lake surface can be estimated from weather conditions and is set at 25 – 50% of the amount of rainfall. Some of the rainfall in the catchment basin is lost through evaporation, but the remaining portion ultimately flows into Lake Biwa *via* the above mentioned river inflow or groundwater infiltration. Approximately 0.01 – 0.2 m^3/m^2 of groundwater is daily entering Lake Biwa through the lake bottom, which estimates the input by groundwater infiltration to be 0.7 – 1.1 billion m^3 per year.

Although the inflow rates from several large rivers can be continuously monitored, these monitoring systems cannot record correct inflow rates during heavy rainfall events. In addition, the lake has many small rivers that lack such monitoring systems. Furthermore, the inflow rates through riverbeds are usually unknown, which are not negligible in some high-bedded rivers. As a result, it is difficult to accurately observe the total volume of inflow into the lake. Hence, the river inflow is usually estimated by calculation of the above mentioned equation.

The water cycle of Lake Biwa and its environs, using the results of past surveys, is shown in Fig. 4-1-1. The total flow rate of river inflow into the lake is approximately 6 billion m^3 of water. The reservoir's holding capacity is 27.5 billion m^3. A combination of the total inflow and the volume of Lake Biwa indicates that water is retained in the lake for approximately five years.

3. Water Cycle in the Basin

Lake Biwa is also a vitally important water resource in its catchment area. The flow rate of water pumped from the lake, e.g., for irrigation in its upstream reaches, can be as high as 300 million m^3 per year. Table 4-1-1 shows a comparison of water intake amount for three utilization purposes: domestic, industrial and agricultural ones. As lake water undergoes less seasonal fluctuations than rivers do, it ensures a stable source for water supply, which is widely used as domestic, industrial, and agricultural water.

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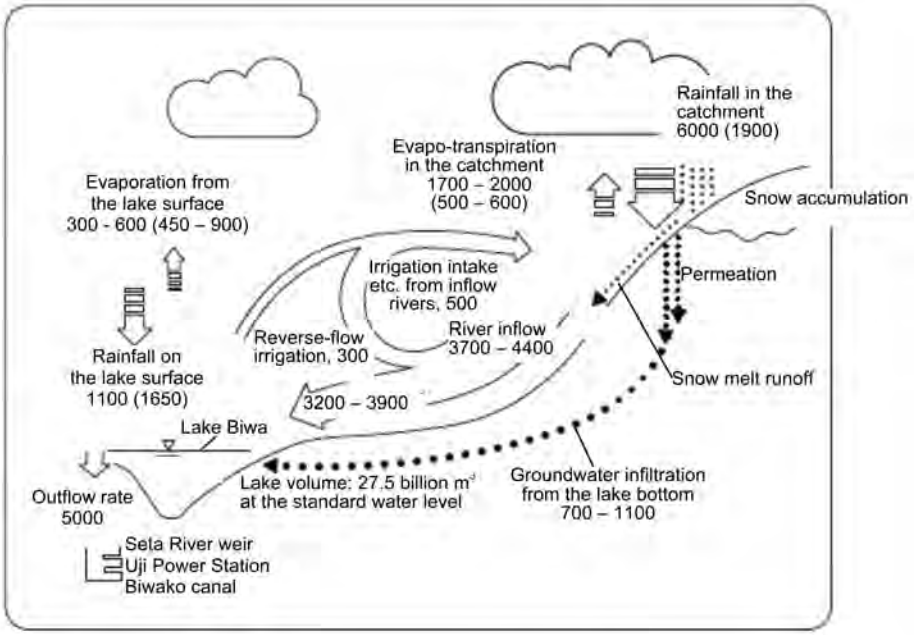

Fig. 4-1-1 The water cycle of Lake Biwa (Water cycle envisaged in 1995)
Unit: million m^3/y (mm/y)

Table 4-1-1 Lake Biwa basin water resources for usage and destinations

(Unit: million m^3/year, values for 1997)

	Total Volume	Water Resource				Destination	
		Lake Biwa	Rivers, *etc*[#]	Recycling	Others[·]	Lake Biwa	Rivers, *etc.*
Domestic	177	125	69	0	-16	69	108
Industrial	640	34	151	440	16	0	200
Agricultural[$]	373	140	233	-	0	126	247

[#] River water, ground water, underground water, *etc.*
[·] Portion of domestic water supply used for industry.
[$] Calculated without considering factors such as rainfall, transpiration and recycling.