

National Institute of Technology Srinagar
Department of Civil Engineering

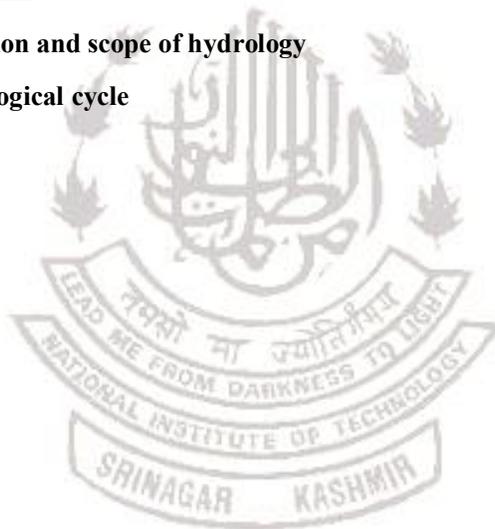
Course Title: Water Resources Engineering
Subject Code: CIV -504

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CONTENT OF LECTURES

LECTURE 1

- 1.1 Definition and scope of hydrology
- 1.2 Hydrological cycle



CHAPTER 1

LECTURE 1

1.1 Definition and scope of hydrology: Hydrology means the science of water. It is the science that deals with the occurrence, circulation and distribution of water of the earth and earth's atmosphere. As a branch of earth science, it is concerned with the water in streams and lakes, rainfall and snow-fall, snow and ice on the land and water occurring below the earth's surface in the pores of the soil and rocks. In a general sense, hydrology is a very broad subject of an inter-disciplinary nature drawing support from allied sciences, such as meteorology, geology, statistics, chemistry, physics and fluid mechanics.

Hydrology is basically an applied science. To further emphasise the degree of applicability, the subject is sometimes classified as

- 1) **Scientific hydrology** – the study which is concerned chiefly with academic aspects.
- 2) **Engineering or applied hydrology** – a study concerned with engineering applications.

In a general sense engineering hydrology deals with

- a) estimation of water resources,
- b) the study of processes such as precipitation, runoff, evapotranspiration and their interaction and
- c) The study of problems such as floods and droughts, and strategies to combat them.

1.2 Hydrological cycle: Water occurs on the earth in all its three states, viz. liquid, solid and gaseous, and in various degrees of motion. Evaporation of water from water bodies such as oceans and lakes, formation and movement of clouds, rain and snowfall, streamflow and groundwater movement are some examples of the dynamic aspects of water. The various aspects of water related to the earth can be explained in terms of a cycle known as the hydrologic cycle.

Figure 1.1 is a schematic representation of the hydrologic cycle. A convenient starting point to describe the cycle is in the oceans. Water in the oceans evaporates due to the heat energy provided by solar radiation. The water vapour moves upwards and forms clouds. While much of the clouds condense and fall back to the oceans as rain, a part of the clouds is driven to the land areas by winds. There they condense and precipitate onto the land mass as rain, snow, hail, sleet, etc. A part of the precipitation may evaporate back to the atmosphere even while falling. Another part may be intercepted by vegetation, structures and other such surface modifications from which it may be either evaporated back to atmosphere or move down to the ground surface.

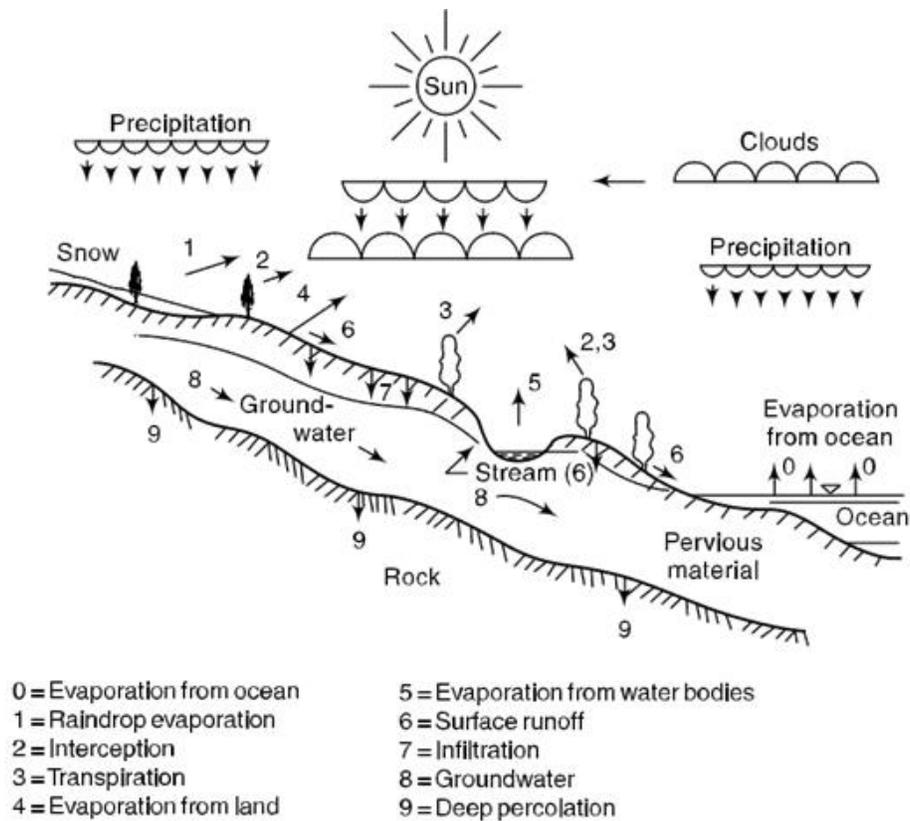


Fig. 1.1 The Hydrologic Cycle

A portion of the water that reaches the ground enters the earth's surface through infiltration, enhance the moisture content of the soil and reach the groundwater body. Vegetation sends a portion of the water from under the ground surface back to the atmosphere through the process of transpiration. The precipitation reaching the ground surface after meeting the needs of infiltration and evaporation moves down the natural slope over the surface and through a network of gullies, streams and rivers to reach the ocean. The groundwater may come to the surface through springs and other outlets after spending a considerably longer time than the surface flow. The portion of the precipitation which by a variety of paths above and below the surface of the earth reaches the stream channel is called runoff. Once it enters a stream channel, runoff becomes stream flow.

The sequence of events as above is a simplistic picture of a very complex cycle that has been taking place since the formation of the earth. It is seen that the hydrologic cycle is a very vast and complicated cycle in which there are a large number of paths of varying time scales. Further, it is a continuous recalculating cycle in the sense that there is neither a beginning nor an end or a pause. Each path of the hydrologic cycle involves one or more of the following aspects:

- 1) Transportation of water,
- 2) Temporary storage and
- 3) Change of state.

For example, (a) the process of rainfall has the change of state and transportation and (b) the groundwater path has storage and transportation aspects.

The main components of the hydrologic cycle can be broadly classified as transportation (flow) components and storage components as below:

Transportation components	Storage components
Precipitation	Storage on the land surface (Depression storage, Ponds, Lakes, Reservoirs, etc)
Evaporation	Soil moisture storage
Transpiration	Groundwater storage
Infiltration	
Runoff	

Schematically the interdependency of transportation components can be represented as in fig 1.2. The quantities of water going through various individual paths of the hydrological cycle in a given system can be described by the continuity principle known as water budget equation or hydrological equation. It is important to note that the total water resources of the earth are constant and the sun is the source of energy for the hydrological cycle. Recognition of the various processes such as evaporation, precipitation and groundwater flow helps one to study the science of hydrology in a systematic way. Also, one realises that man can interfere with virtually any part of the hydrologic cycle, e.g. through artificial rain, evaporation suppression, change of vegetal cover and land use, extraction of groundwater, etc. Interference at one stage can cause serious repercussions at some other stage of the cycle.

The hydrological cycle has important influences in a variety of fields including agriculture, forestry, geography, economics, sociology and political scene. Engineering applications of the knowledge of the hydrologic cycle, and hence of the subjects of hydrology, are found in the design and operation of projects dealing with water supply, irrigation and drainage, water power, flood control, navigation, coastal works, salinity control and recreational uses of water.

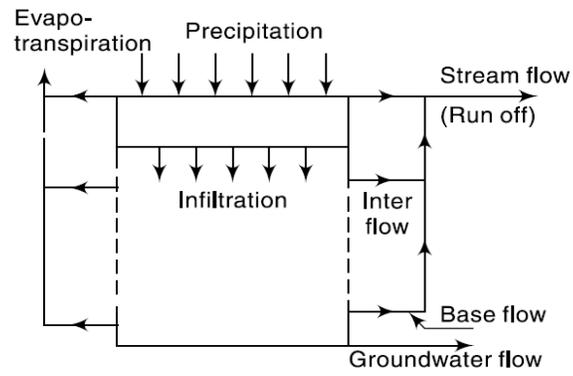


Fig. 1.2 Transportation Components of the Hydrologic Cycle



1.3 Catchment Area: The area of land draining into a stream or a water course at a given location is known as catchment area. It is also called as drainage area or drainage basin. In USA, it is known as watershed. A catchment area is separated from its neighbouring areas by an area of land draining into a stream or a water course at a given location is known as catchment area. It is also called as drainage area or drainage basin. In USA, it is known as watershed. A catchment area is separated from its neighbouring areas by a ridge called divide in USA and watershed in UK (Fig. 1.3). The areal extent of the catchment is obtained by tracing the ridge on a topographic map to delineate the catchment and measuring the area by a planimeter. It is obvious that for a river while mentioning the catchment area the station to which it pertains (Fig. 1.3) must also be mentioned. It is normal to assume the groundwater divide to coincide with the surface divide. Thus, the catchment area affords a logical and convenient unit to study various aspects relating to the hydrology and water resources of a region.

Further it is probably the single most important drainage characteristic used in hydro-logical analysis and design.

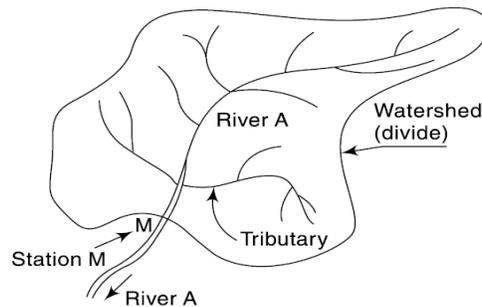
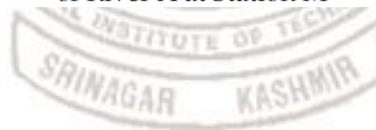


Fig. 1.3 Schematic Sketch of Catchment of River A at Station M



1.4 Water Budget Equation: For a given problem area, say a catchment, in an interval of time Δt , the continuity equation for water in its various phases is written as

$$\text{Mass inflow} - \text{mass outflow} = \text{change in mass storage}$$

If the density of the inflow, outflow and storage volumes are the same

$$V_i - V_o = \Delta S \quad (1.1)$$

where V_i = inflow volume of water into the problem area during the time period, V_o = outflow volume of water from the problem area during the time period, and ΔS = change in the storage of the water volume over and under the given area during the given period. In applying this continuity equation to the paths of the hydrologic cycle involving change of state, the volumes considered are the equivalent volumes of water at a reference temperature. In hydrologic calculations, the volumes are often expressed as average depths over the catchment area. Thus, for example, if the annual stream flow

from a 10 km² catchment is 10⁷ m³, it corresponds to a depth of 1 m = 100 cm. Rainfall, evaporation and often runoff volumes are expressed in units of depth over the catchment. While realizing that all the terms in a hydrological water budget may not be known to the same degree of accuracy, an expression for the water budget of a catchment for a time interval Δt is written as

$$P - R - G - E - T = \Delta S \quad (1.2)$$

In this

P = precipitation,

R = surface runoff,

G = net groundwater flow out of the catchment,

E = evaporation,

T = transpiration and

ΔS = change in storage.

The storage S consists of three components as

$$S = S_s + S_{sm} + S_g \quad (1.3)$$

Where

S_s = surface water storage

S_{sm} = water in storage as soil moisture and

S_g = water in storage as groundwater.

Thus

$$\Delta S = \Delta S_s + \Delta S_{sm} + \Delta S_g \quad (1.4)$$

All terms in Eq. (1.4) have the dimensions of volume. Note that all these terms can be expressed as depth over the catchment area (e.g. in centimetres), and in fact this is a very common unit.

In terms of rainfall/runoff relationship,

$$R = P - L \quad (1.6)$$

Where L = Losses = water not available to runoff due to infiltration (causing addition to soil moisture and groundwater storage), evaporation, transpiration and surface storage.