Module 5

4 Lectures

Flood Routing

Prof. Subhankar Karmakar

IIT Bombay

The objective of this module is to introduce the concepts and methods of lumped and distributed flood routing along with an insight into Muskingum method.

Topics to be covered

- **Lumped flow routing**
  - Level pool method
  - Kinematic wave/Channel routing
    - ➔ Muskingum method
- **Distributed Flow routing**
  - Diffusion wave routing
    - ➔ Muskingum-Cunge method
  - Dynamic wave routing

Module 5

Lecture 1: Introduction to flood routing

Flood Routing

"Flood routing is a technique of determining the flood hydrograph at a section of a river by utilizing the data of flood flow at one or more upstream sections."

(Subramanya, 1984)

Applications of Flood Routing

For accounting changes in flow hydrograph as a flood wave passes downstream

Flood:

- Flood Forecasting
- Flood Protection
- Flood Warning

Design:

- Water conveyance (Spillway) systems
- Protective measures
- Hydro-system operation

Water Dynamics:

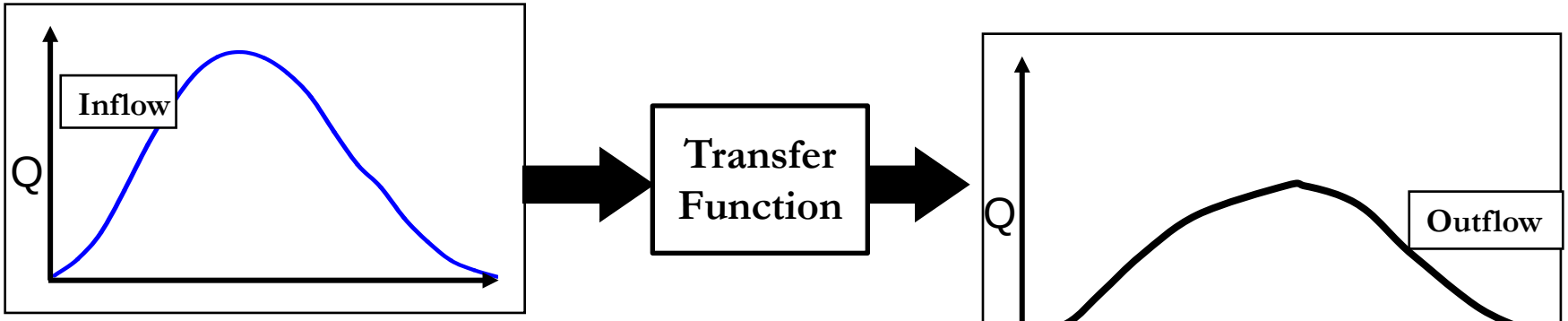
- Ungauged rivers
- Peak flow estimation
- River-aquifer interaction

Types of flood routing

- **Lumped/hydrologic**
  - Flow→ f(time)
  - Continuity equation and Flow/Storage relationship
- **Distributed/hydraulic**
  - Flow → f(space, time)
  - Continuity and Momentum equations

Flow Routing Analysis

It is a procedure to determine the flow hydrograph at a point on a watershed from a known hydrograph upstream.



$I(t) = \text{Inflow}$

Upstream hydrograph

$Q(t) = \text{Outflow}$

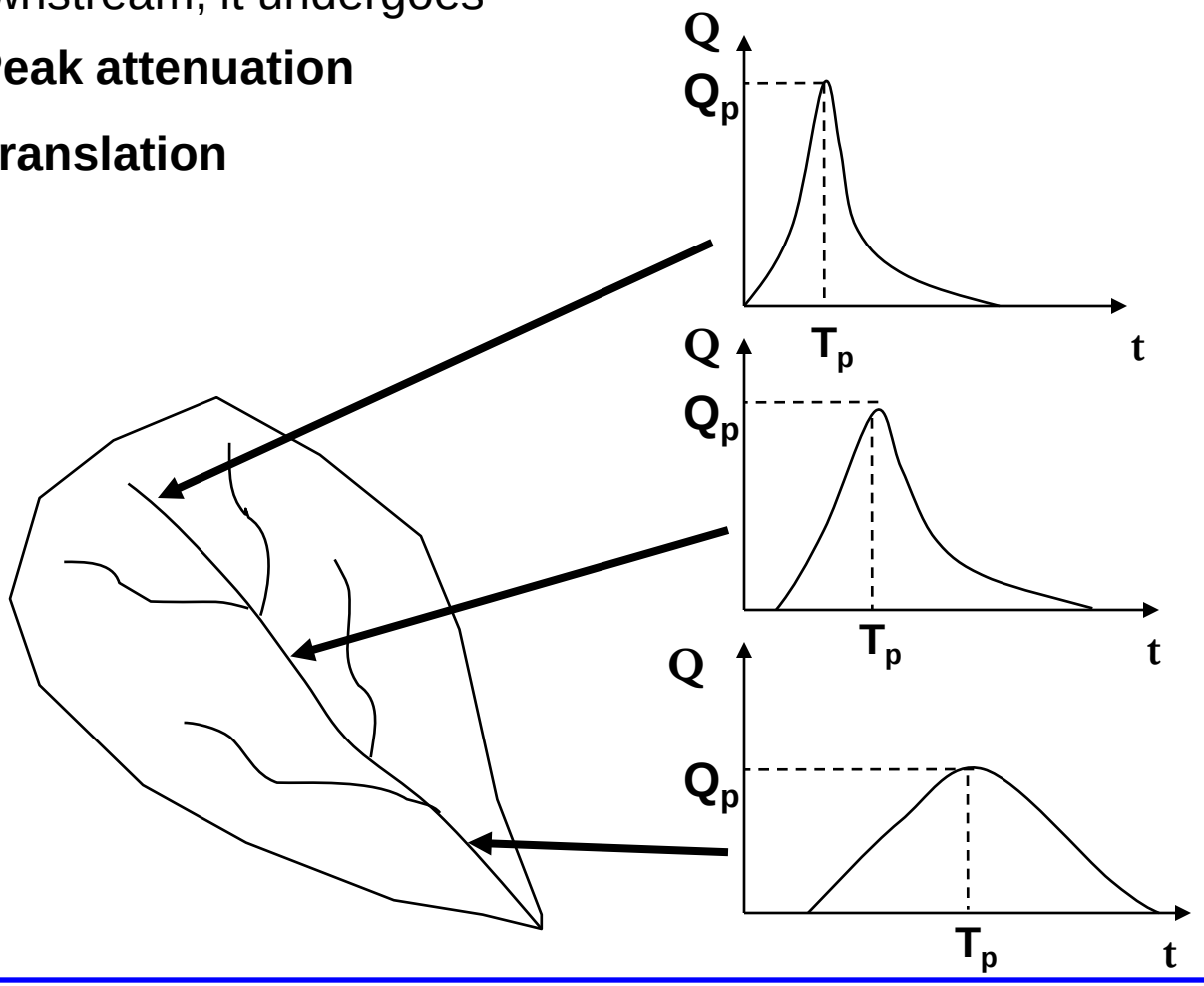
Downstream hydrograph

Flow Routing Analysis

Contd…

As flood wave travels downstream, it undergoes

- **Peak attenuation**
- **Translation**



Flood Routing Methods

Lumped / Hydrologic flow routing:

- Flow is calculated as a function of time alone at a particular location.
- Hydrologic routing methods employ essentially the equation of continuity and flow/storage relationship

Distributed / Hydraulic routing:

- Flow is calculated as a function of space and time throughout the system
- Hydraulic methods use continuity and momentum equation along with the equation of motion of unsteady flow (St. Venant equations).

Hydrologic routing

1. **Level pool method (Modified Puls)**
   - Storage is nonlinear function of Q
   - Reservoir routing
2. **Muskingum method**
   - Storage is linear function of I and Q
   - Channel routing
3. **Series of reservoir models**
   - Storage is linear function of Q and its time derivatives

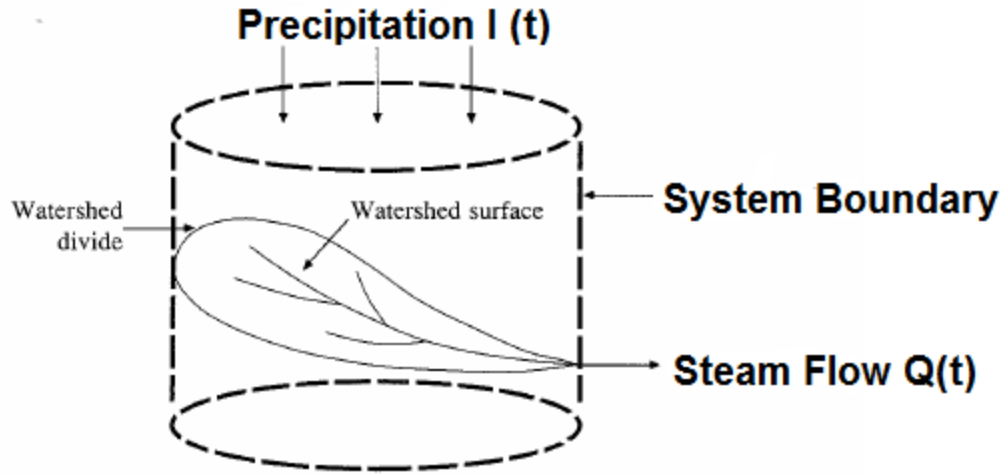
Continuity equation for hydrologic routing

Flood hydrograph through a reservoir or a channel reach is a gradually varied unsteady flow. If we consider some hydrologic system with input I(t), output Q(t), and storage S(t), then the equation of continuity in hydrologic routing methods is the following:

$$I - Q = \frac{\Delta S}{\Delta t}$$

ΔS ⟶ Change in storage

Δt ⟶ Change in time



Hydrologic system of a catchment

Continuity equation for hydrologic routing

Contd..

Rate change of flow storage can be also represented by this following equation:

$$I - Q = \frac{\Delta S}{\Delta t}$$

ΔS → Change in storage

Δt → Change in time

Even if the inflow hydrograph, I(t) is known, this equation cannot be solved directly to obtain the outflow hydrograph, Q(t), because both Q and S are unknown. A second relation, the storage function is needed to relate S, I, and Q. The particular form of the storage equation depends on the system: a reservoir or a river reach.