Flood Routing

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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 $\rightarrow f(\text{time})$
  - Continuity equation and Flow/Storage relationship

- **Distributed/hydraulic**
  - Flow $\rightarrow f(\text{space, time})$
  - 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.

\[ I(t) = \text{Inflow} \]

\[ Q(t) = \text{Outflow} \]

**Upstream hydrograph**

**Downstream hydrograph**
As flood wave travels downstream, it undergoes

- Peak attenuation
- Translation

\[ Q_p \]

\[ T_p \]
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:

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

- $I - Q$ Change in storage
- $\frac{\Delta S}{\Delta t}$ Change in time

[Diagram of hydrologic system of a catchment]
Rate change of flow storage can be also represented by this following equation:

\[ I - Q = \frac{\Delta S}{\Delta t} \]

This equation relates the change in storage \( \Delta S \) to the difference between the inflow \( I \) and outflow \( Q \). 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.