Hydrologic Engineering Center
Hydrologic Modeling System (HEC-HMS)

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Exercise

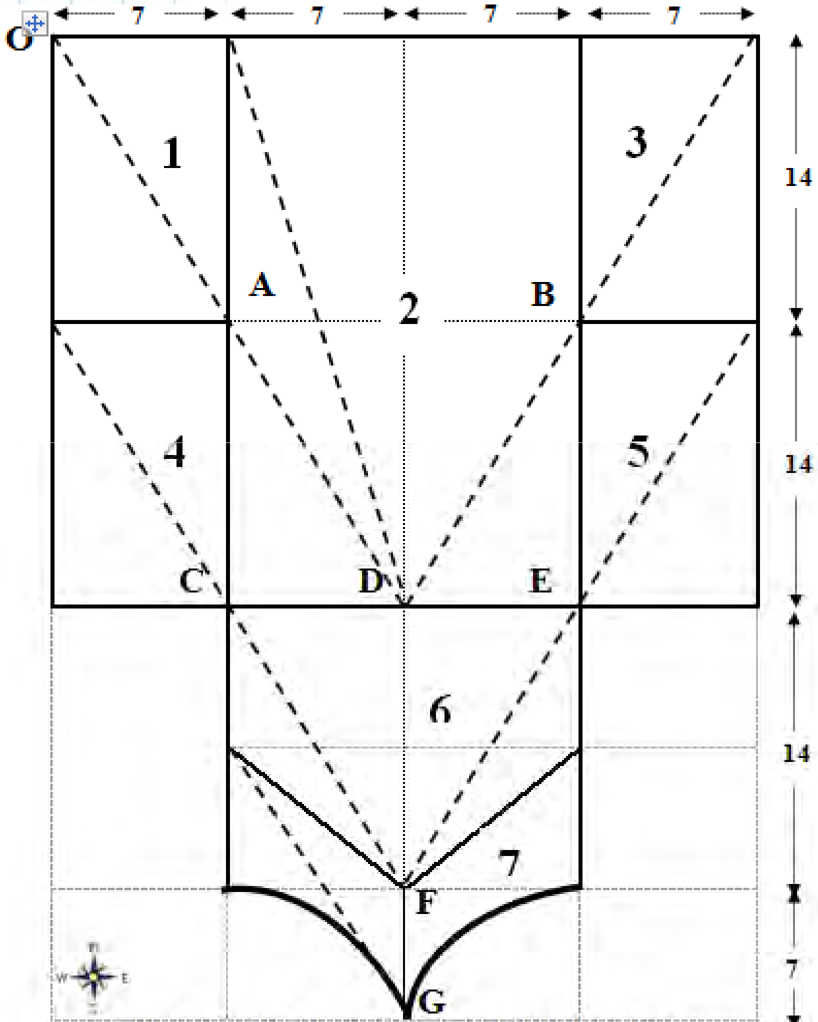


Fig1: Basin/Sub-Basins for Rainfall-Runoff Analysis

Objective:

To determine hydrological Response of the given basin for 500 years return period event.

Assignment

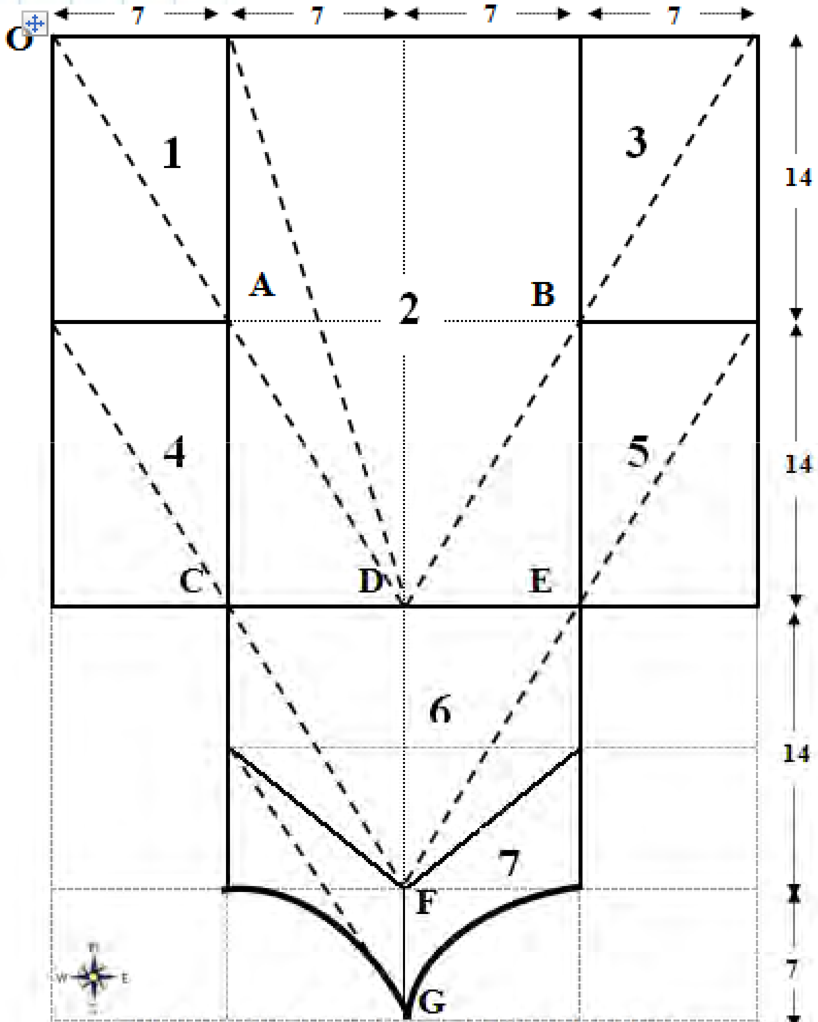


Fig1: Basin/Sub-Basins for Rainfall-Runoff Analysis

<u>This analysis consists of two parts:</u>

1. To estimate the IDF-curve & Design Storm using formulae given.
2. To determine the hydrological response of the Design storm over the basin using software tool HEC-HMS and to reduce the peak flow by adjusting elevation & length of the spillway.

Assignment

Year	Rainfall mm	Year	Rainfall mm	Year	Rainfall mm
1975	124	1985	54.4	1995	61.9
1976	66.4	1986	63.6	1996	97.5
1977	52.1	1987	52.5	1997	82.4
1978	40.1	1988	29.7	1998	55.5
1979	76.5	1989	112.6	1999	63.6
1980	73.4	1990	42.8	2000	31.3
1981	47.4	1991	46.6	2001	63.5
1982	82.2	1992	48.3	2002	87.1
1983	34.2	1993	230.1	2003	77.7
1984	48.5	1994	67.2	2004	60.1

Estimation of IDF Curve & Design Storm

Gumbel Analysis:

$$X_T(T) = \overline{X} + K\sigma$$

$\overline{X}$ = Mean of the Sample,

σ = Standard deviation of the Sample,

$$K = Frequency - factor = \frac{y_T - y_n}{S_n},$$

y_n = Reduced mean, S_n = Reduced standard deviation

$$y_T = ReducedVariate = -[\ln.\ln\frac{T}{T-1}]$$

T = Return Period.

Estimation of IDF Curve & Design Storm

IDF Curve & Design Storm:

$$\text{Intensity, } I = \frac{X_T}{24} * RF^{\frac{28^{(0.1)} - D^{(0.1)}}{28^{(0.1)} - 1}},$$

Where,

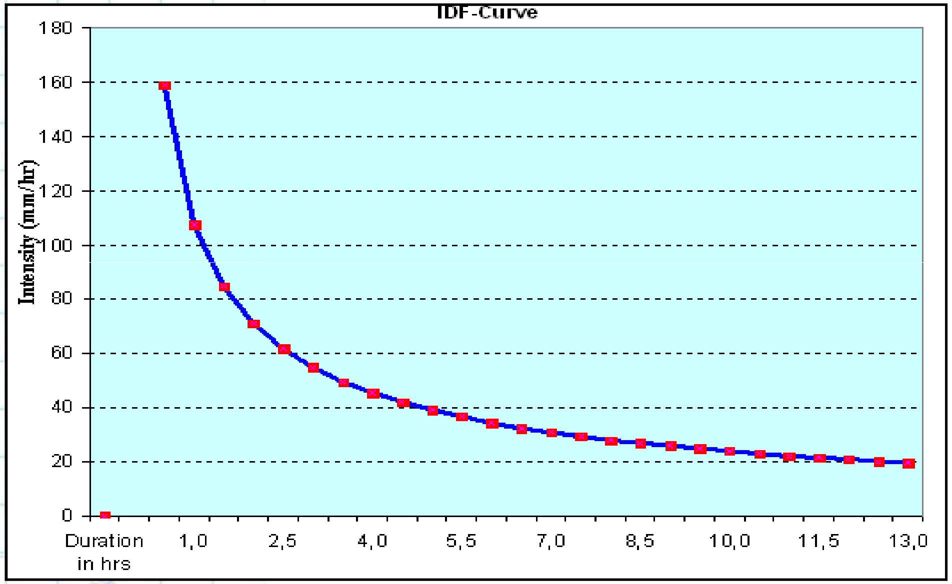
X_T = Max^m Rainfall in 24 hrs for T years return period.

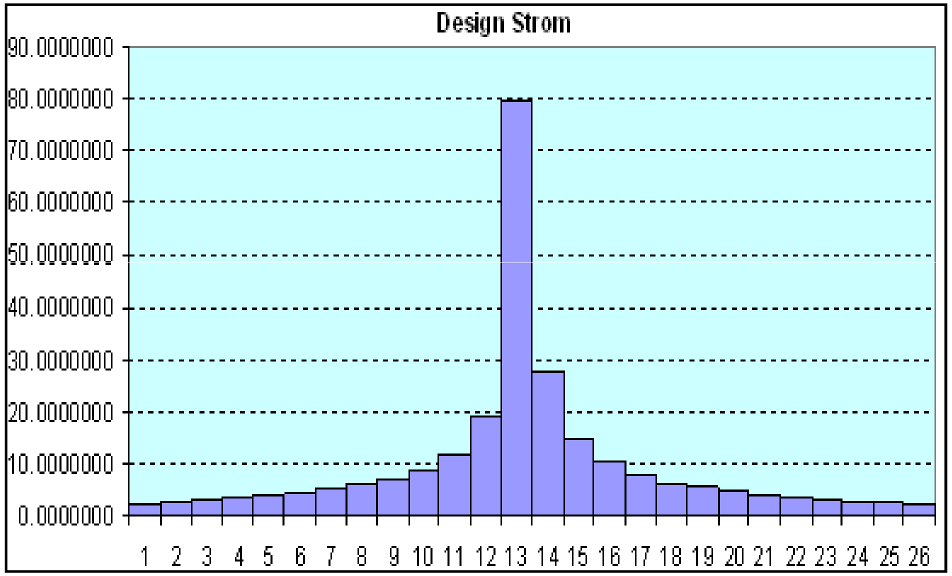
Regional Factor, RF = 10,

D = Duration in hours.

Estimation of IDF Curve & Design Storm

IDF Curve & Design Storm:

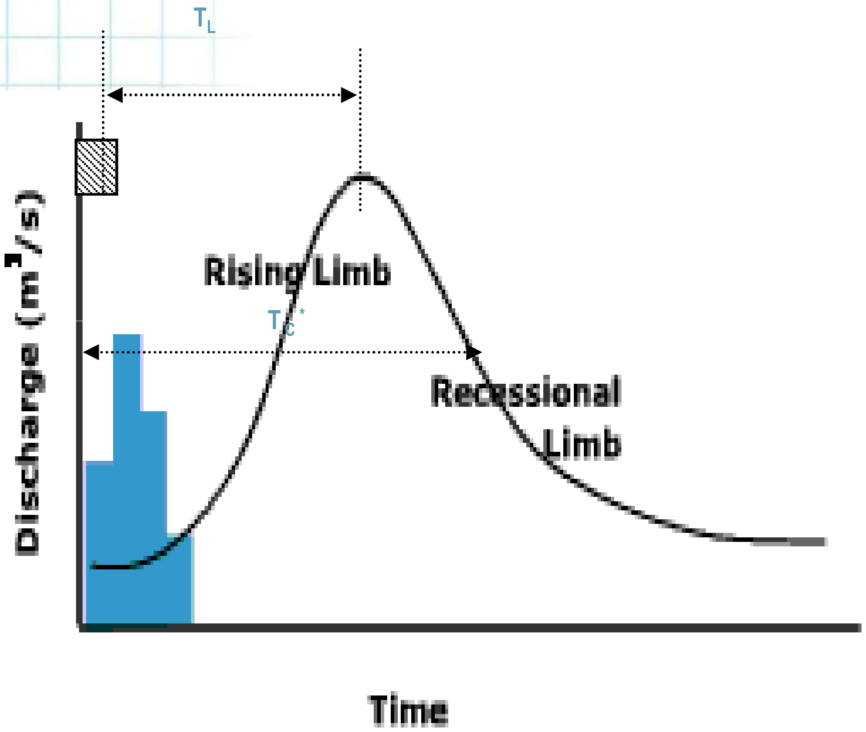




Rainfall-Runoff Modelling: HEC-HMS

- Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS)
- A product of HEC under USACE
- First version HEC-1 in 1992
- Latest is HEC-3.5
- Designed to simulate Rainfall-runoff
- Small urban watershed to large river basin
- Incorporates range of hydrological concepts

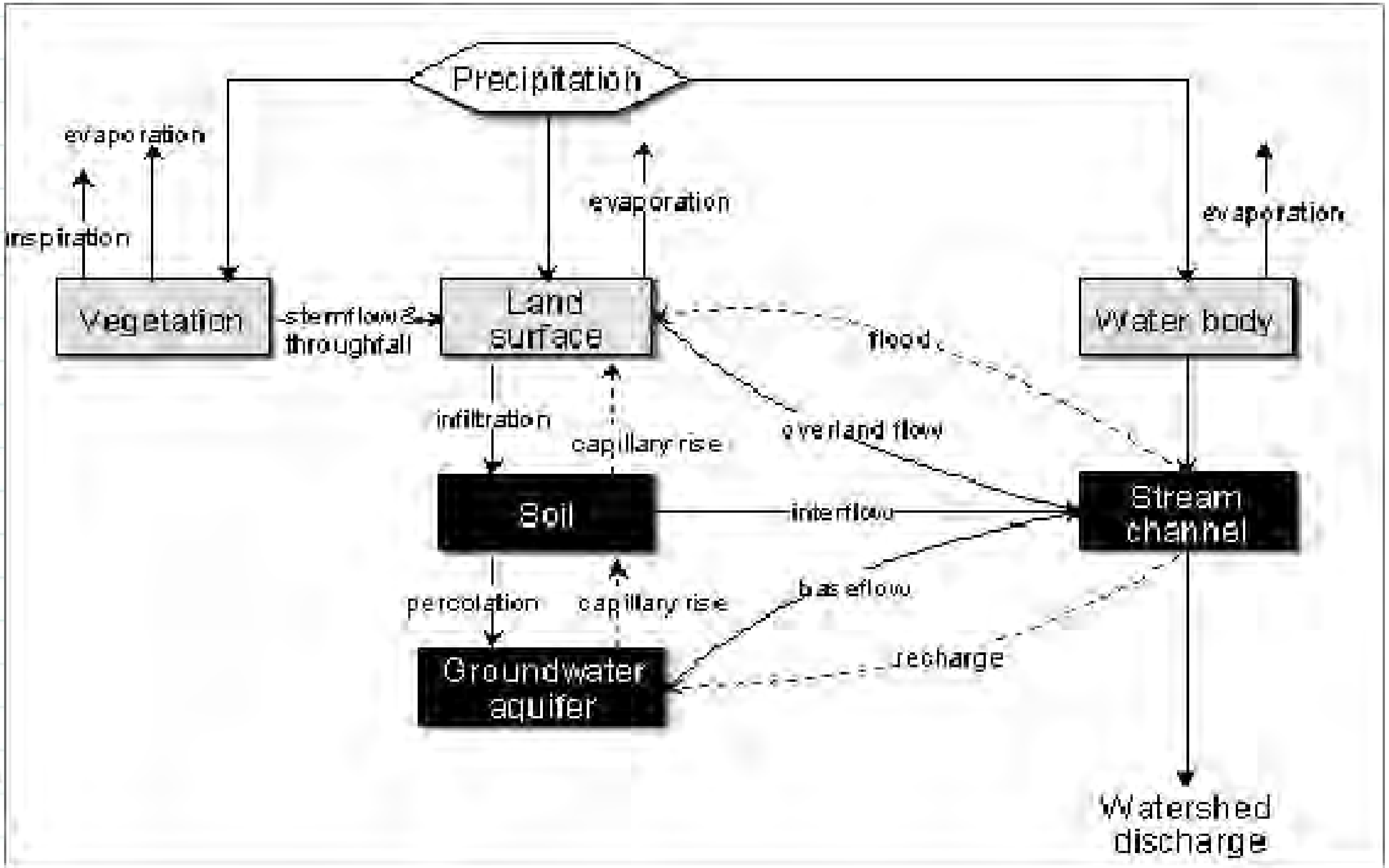
Rainfall-Runoff



Parameters:

- Slope.
- Soil type.
- Antecedent Moisture Condition.
- Vegetation.
- Landuse etc.

Rainfall-Runoff



Time of Concentration

Time taken by a raindrop to travel from the farthest point to the exit of the basin.

$$T = 0.3\left(\frac{L}{J^{0.25}}\right)^{0.76}$$

T= Time of Concentration, if and only if,

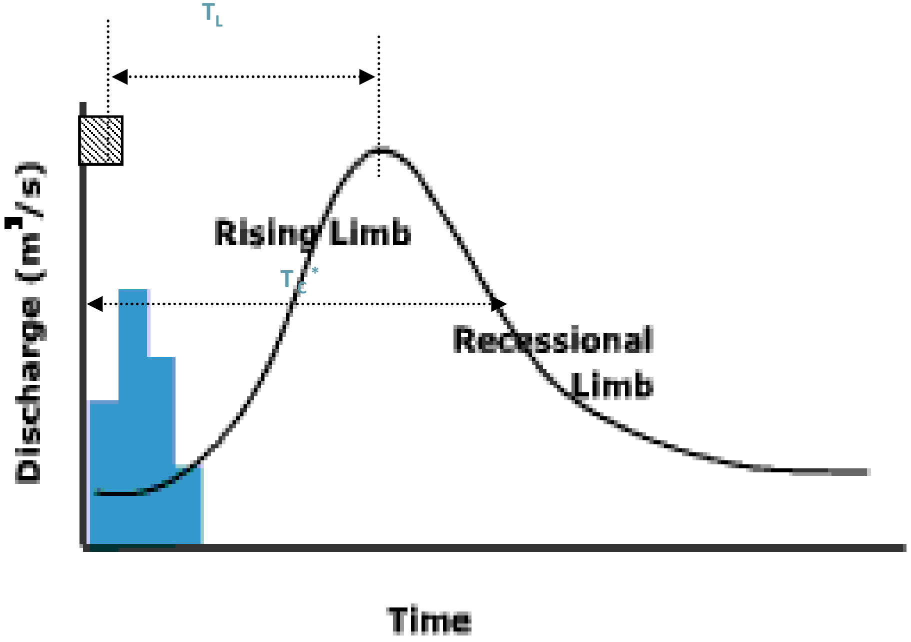
L=maximum possible length traveled by a rain drop in a basin.

Basic Hydrological Concepts : HEC-HMS

Lag Time

In a hydrograph, the time elapsed from the Centroid of the effective rainfall to the peak discharge is generally called the lag time (T_L). But Soil Conservation Services has modified the value of lag time as under:

$$T_{lag} = 0.6T_C^{\ *} \cong 0.35T_C$$



Basic Hydrological Concepts : HEC-HMS

Loss Methods:

1. Deficit & Constant Loss
2. Exponential Loss
3. Green & Ampt Loss
4. Gridded Deficit Constant Loss
5. Gridded Grid and Ampt Loss
6. Gridded SCS Curve Number Loss

Basic Hydrological Concepts : HEC-HMS

Loss Methods (contd..):

7. Gridded Soil Moisture Accounting
8. Initial & constant Loss
9. SCS Curve Number Loss
10. Smith Parlange Loss
11. Soil Moisture Accounting Loss

SCS Curve Number (CN) Loss Method

$$Q = \frac{(P - I_a)^2}{P - I_a + S}$$

$$S = \frac{25400}{CN} - 254$$

$$I_a = \lambda \times S$$

Where

Q = Direct surface runoff;

P = Total precipitation;

I_a = the initial abstraction (initial loss); and

S = potential maximum retention

λ = A fraction ranging from 0.1 to 0.4

CN= Curve Number ranging from 0 to 100

Basic Hydrological Concepts : HEC-HMS

SCS Curve Number (CN) Loss Method

Soil Type

Land Use/ Land Cover

Antecedent Moisture Condition

Basic Hydrological Concepts : HEC-HMS

Soil Type

Group-A: Low runoff potential

Soils having high infiltration rates, Eg- Deep sand, loess, aggregated silt

Group-B: Moderately low runoff potential

Eg- Shallow loess, sandy loam, red loamy soil, red sandy soil

Group-C: Moderately high runoff potential

Soils having low infiltration rates, Eg- soils high in clay, clayey loom, shallow sandy loam, black soils.

Group-D: High runoff potential

Soils having very low infiltration rates, Eg- Heavy plastic clay, deep black soil, saline soils

Basic Hydrological Concepts : HEC-HMS

Curve Number: Land use/ Land cover


Cultivated


Forest


Orchard


Pasture


Wasteland


Urban

Basic Hydrological Concepts : HEC-HMS

Antecedent Moisture Condition

AMC-I: Soils are dry but not to wilting point

AMC-II: Average Condition

AMC-III: Saturated soil condition

Basic Hydrological Concepts : HEC-HMS

Transform Methods:

1. Clark Unit Hydrograph
2. Kinematic Wave
3. ModClark
4. SCS Unit Hydrograph
5. Snyder Unit Hydrograph
6. User Specified S-Graph
7. User Specified Unit Hydrograph

Basic Hydrological Concepts : HEC-HMS

SCS Unit Hydrograph:

$$Q_P = C\frac{A}{T_P}$$

$$T_P = \frac{\Delta t}{2} + T_{lag}$$

Where

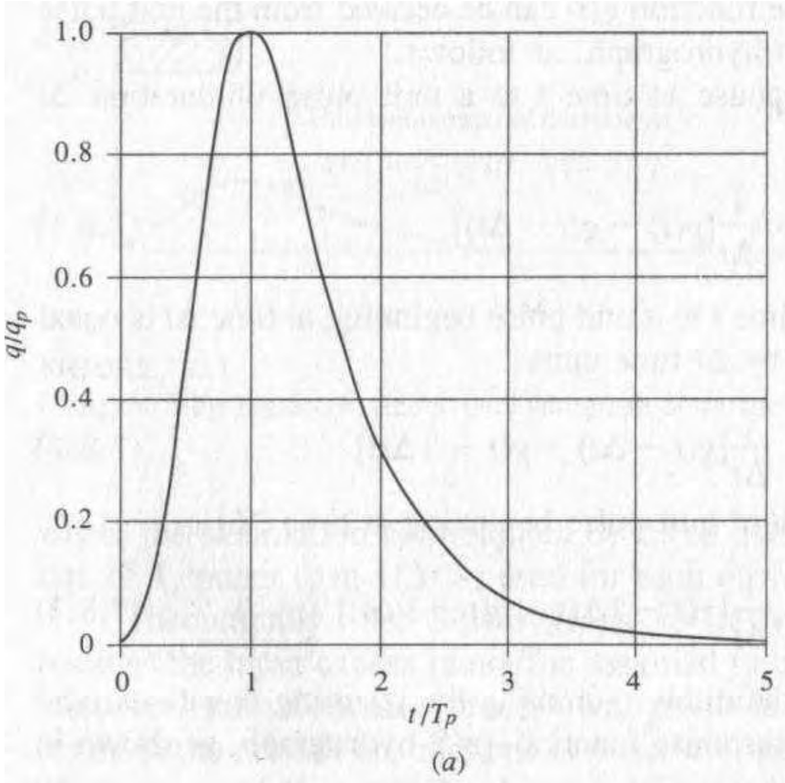
Q_p = Peak discharge;

C = Conversion Constant;

A = Area of the basin; and

T_p= Time to peak

Δt = Duration of unit hydrograph



Basic Hydrological Concepts : HEC-HMS

Routing Methods:

1. Kinematic Wave
2. Lag
3. Modified Pul
4. Muskingum
5. Muskingum-Cung
6. Straddle-Stagger

Routing Process

Muskingum Equation: $S = K[x I + (1-x) Q]$

Where,

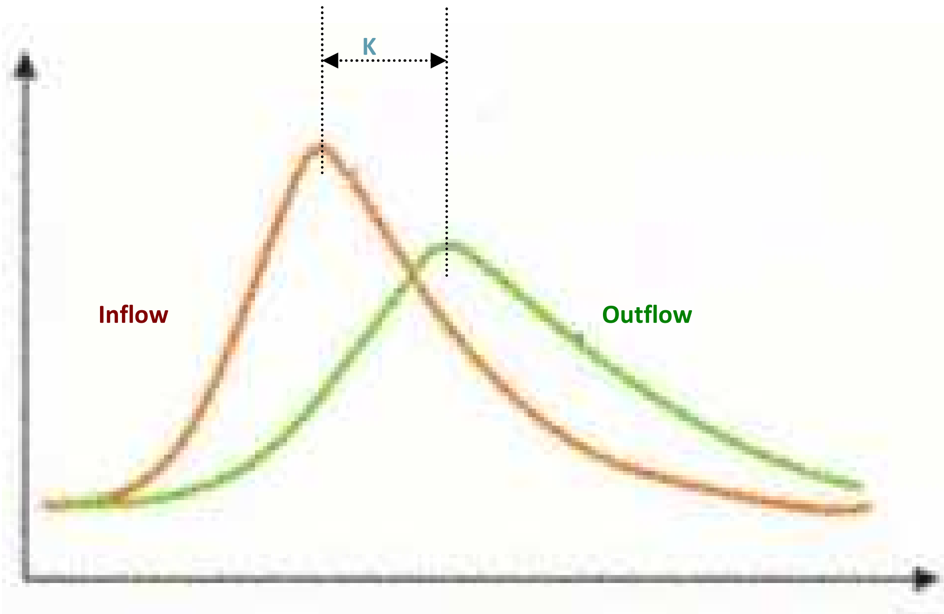
S= storage,

I=Inflow,

Q=Outflow discharge,

K= storage time constant,

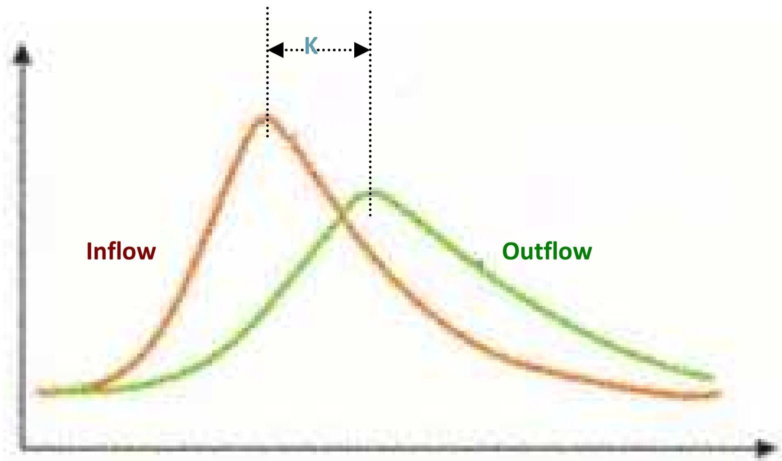
x= weighting factor.



Estimation of K, Muskingum Equation

$$K_{reach} = 0.6T_{reach}$$

$$T_{reach} \cong 0.3\left(\frac{L}{J^{0.25}}\right)^{0.76}$$



Muskingum Equation: S= K[x I + (1-x) Q]

Estimation of x, Muskingum Equation

Muskingum Equation: $S = K[x I + (1-x) Q]$

When $x=0$, $S=KQ$,

Storage is a function of outflow discharge only (i.e. prism storage).

When $x=0.5$,

Storage is known as linear storage, equally depends on inflow and outflow

Natural channel,

x ranges between 0 & 0.5 (most likely around 0.3).

The flow upstream is guided by the Inflow & downstream by outflow, therefore, x of upstream must be more than x of downstream.

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January 29th 2015 – NWA, Pune