Reservoir Planning

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Dams are constructed across the rivers and streams to create an artificial lake behind it.

What is a Reservoir?

- It is an area developed by water body due to construction of dam.

Storage reservoir serve the following purpose :

- Irrigation
- Water supply
- Hydroelectric power generation
- Flood control
- Navigation
- Recreation
- Development of fish & wild life
- Soil conservation

Classification

- **Storage Reservoirs:** Storage reservoirs are also called conservation reservoirs because they are used to conserve water. Storage reservoirs are constructed to store the water in the rainy season and to release it later when the river flow is low

- **Flood Control Reservoirs:** A flood control reservoir is constructed for the purpose of flood control. It protects the areas lying on its downstream side from the damages due to flood.

- **Retarding Reservoirs:** A retarding reservoir is provided with spillways and sluiceways which are ungated. The retarding reservoir stores a portion of the flood when the flood is rising and releases it later when the flood is receding.

- **Detention Reservoirs :** A detention reservoir stores excess water during floods and releases it after the flood. It is similar to a storage reservoir but is provided with large gated spillways and sluiceways to permit flexibility of operation.

- **Distribution Reservoirs:** A distribution reservoir is a small storage reservoir to tide over the peak demand of water for municipal water supply or irrigation. The distribution reservoir is helpful in permitting the pumps to work at a uniform rate. It stores water during the period of lean demand and supplies the same during the period of high demand.

- **Multipurpose Reservoirs:** The are constructed for more than single purpose.

- **Balancing Reservoirs:** A balancing reservoir is a small reservoir constructed d/s of the main reservoir for holding water released from the

INVESTIGATIONS FOR RESERVOIR PLANNING

- 1. Engineering surveys
- 2. Geological investigations
- 3. Hydrological investigations

ENGINEERING SURVEYS

- Area of the site (dam site, reservoir and associated works) surveyed and contour map of the entire area is prepared
- From contour map, storage capacity and water spread area of reservoir at various elevations can be determined
  - Water spread area at any elevation determined by measuring the area enclosed by the contour corresponding to that elevation with a planimeter
  - Storage capacity of reservoir determined by taking contour areas at equal interval and summing up by trapezoidal formula, cone formula or prismoidal formula

Draw a neat sketch of Area-Capacity elevation curve. Describe how to interpret various parameters from this curve.

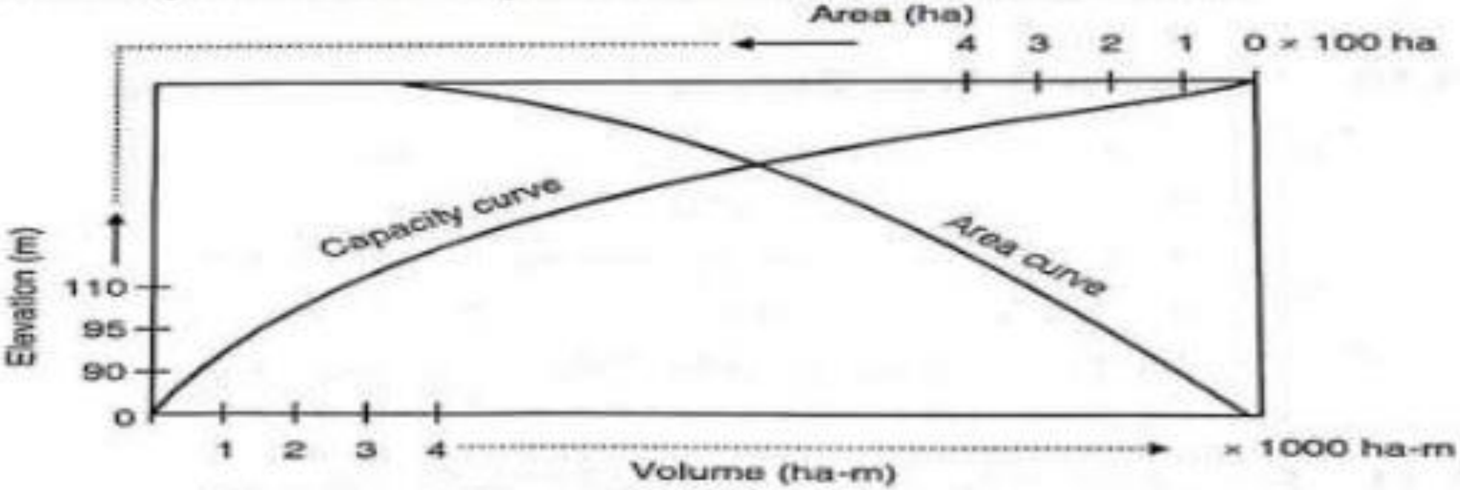


Fig. Area-Capacity elevation curve

1) Area capacity curve is a curve in which two curves are plotted in one graph having area in hectares of water spread and reservoir capacity plotted at x and y axis resp.

2) The area curve gives information about area under submergence and useful in determining control level of dam.

3) The capacity curve provides the information about capacity of reservoir which is useful in deciding capacity of reservoir.

4) From the contour map of reservoir area, the water spread of the reservoir at any elevation is directly determined by measuring area at that contour with the help of planimeter.

5) The capacity may be determined by taking contour areas at equal intervals and summing up these areas by following methods:

a) Trapezoidal formula

b) Prismoidal formula

GEOLOGICAL INVESTIGATIONS

- Geological investigations required to determine
  - Suitability of foundation for dam
  - Water tightness of the reservoir basin
  - Location of quarry sites for obtaining suitable construction materials

HYDROLOGICAL INVESTIGATIONS

- To estimate the quantity of water likely o be available in river
  - Study of runoff pattern of river at the proposed dam site to determine the storage capacity of reservoir
  - Determination of hydrograph of the worst flood to determine the spillway capacity and design

SELECTION OF SITE FOR A RESERVOIR

- 1. Suitable dam site must be available
- 2. River valley at site
  - Narrow so that the length of dam is less
  - Open out at u/s to provide large basin for reservoir storage
- 3. Surrounding hills must be watertight
- 4. Reservoir basin should be water tight

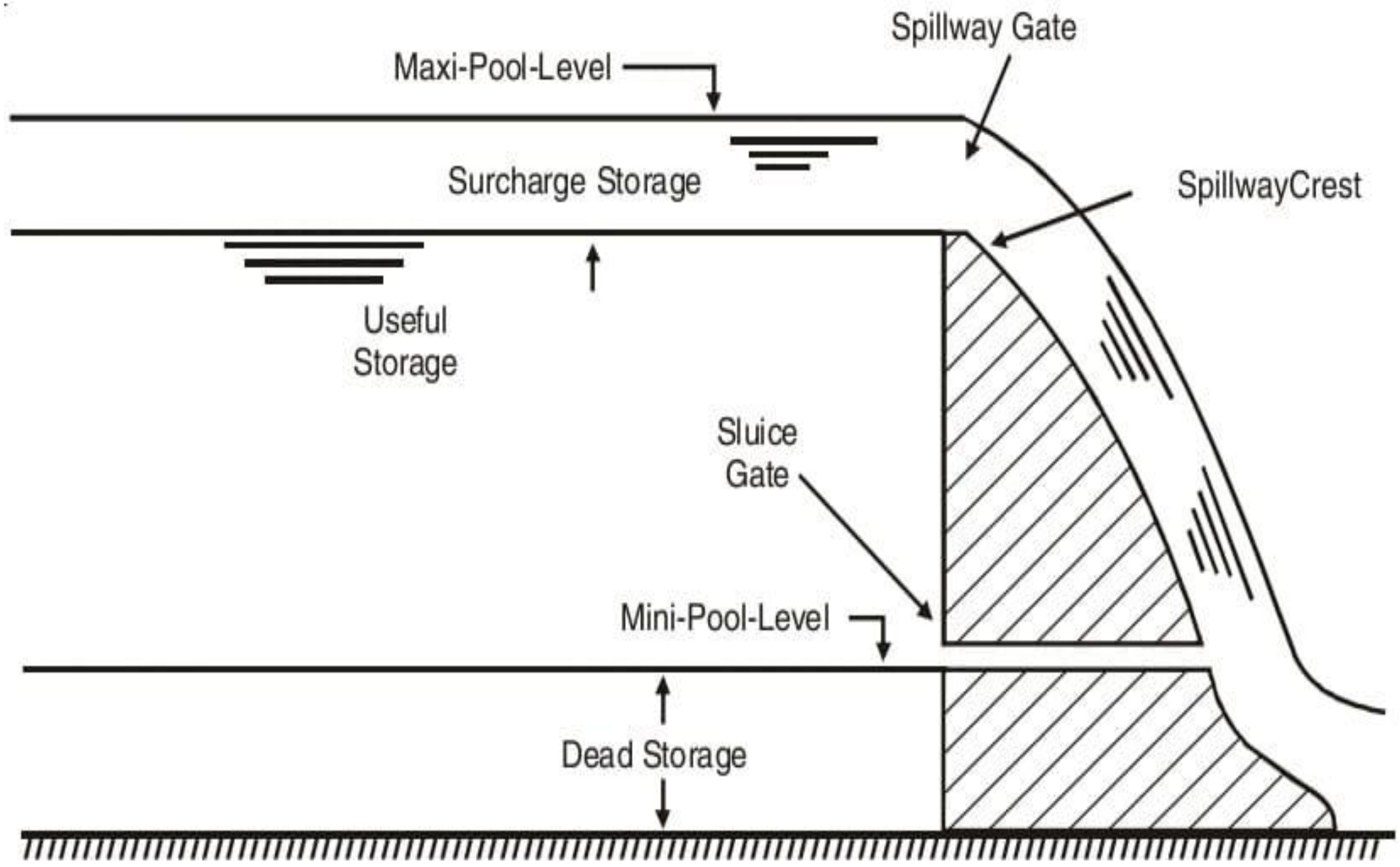
SELECTION OF SITE FOR A RESERVOIR...

- 5. Site should be such that minimum land and property is submerged in the reservoir
- 6. Site should be such that it should avoid those tributaries which carries unusually high sediment content
- 7. Site should be such that adequate reservoir capacity must be made available

SELECTION OF SITE FOR A RESERVOIR…

- 8. As far as possible a deep reservoir must be formed
  - Land cost per unit capacity is low
  - Less evaporation loss
  - Less weed growth
- 9. No minerals and objectionable salts present
- 10.Quality of water available in reservoir should be of good

Zones of Storage



- **Full reservoir level (FRL):** The full reservoir level (FRL) is the highest water level to which the water surface will rise during normal operating conditions.

- **Maximum water level (MWL):** The maximum water level is the maximum level to which the water surface will rise when the design flood passes over the spillway.

- **Minimum pool level:** The minimum pool level is the lowest level up to which the water is withdrawn from the reservoir under ordinary conditions.

- **Dead storage:** The volume of water held below the minimum pool level is called the dead storage. It is provided to cater for the sediment deposition by the impounding sediment laid in water. Normally it is equivalent to volume of sediment expected to be deposited in the reservoir during the design life reservoir.

- **Live/useful storage:** The volume of water stored between the full reservoir level (FRL) and the minimum pool level is called the useful storage. It assures the supply of water for specific period to meet the demand.

- **Bank storage:** is developed in the voids of soil cover in the reservoir area and becomes available as seepage of water when water levels drops down. It increases the reservoir capacity over and above that given by elevation storage curves.

- **Valley storage:** The volume of water held by the natural river channel in its valley up to the top of its banks before the construction of a reservoir is called the valley storage. The valley storage depends upon the cross section of the river.

- **Flood/Surcharge storage:** is storage contained between maximum reservoir level and full reservoir levels. It varies with spillway capacity of dam for given design flood.

Storage Capacity and Yield

Yield is the amount of water that can be supplied from reservoir in a specified interval of time.

Arithmetic average of safe yield and secondary yield over a long period of time

MASS INFLOW CURVE

- Mass inflow is a curve which represents the cumulative flow in a reservoir at any particular instance.
- It is a plot between cumulative inflow in the reservoir with time.
- It can be prepared with the help of a hydrograph of the river for the dam site for a large number of years.
- We know hydrograph is a plot or curve between discharge versus time.

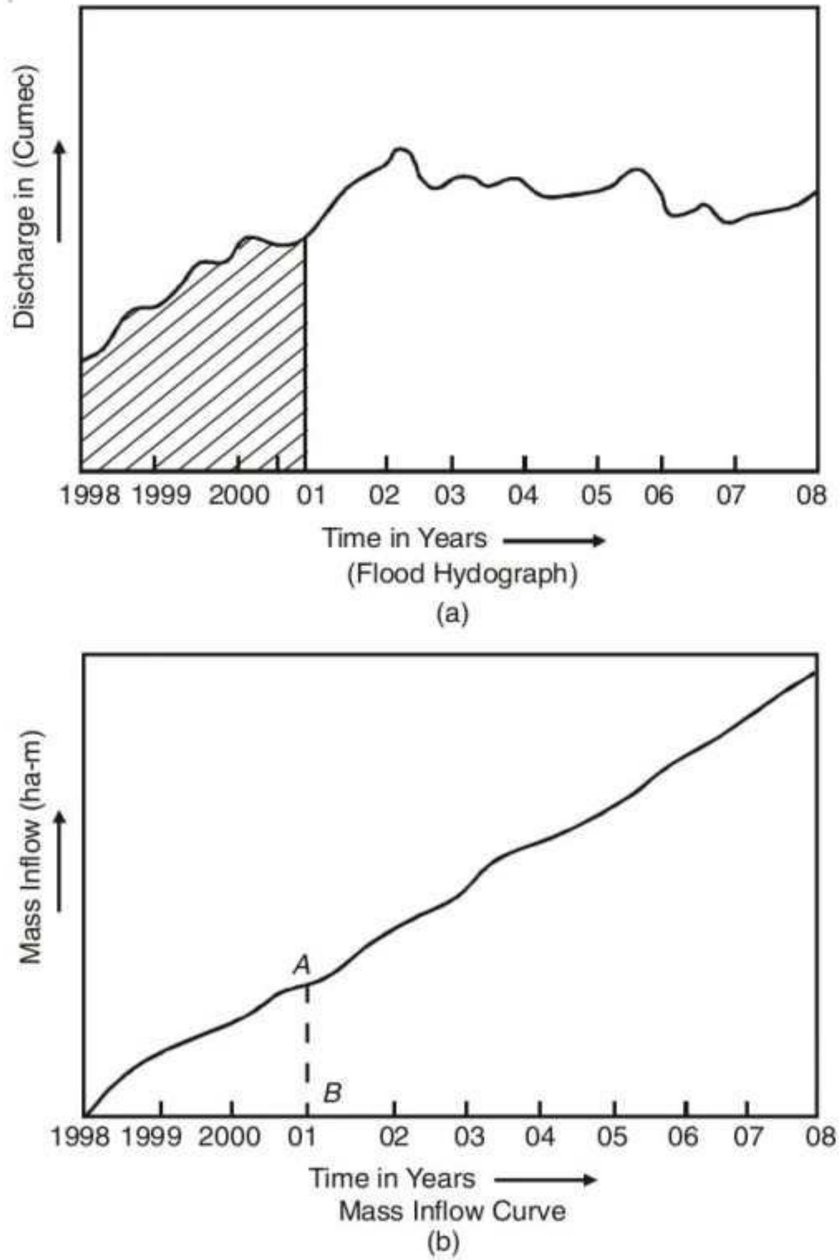
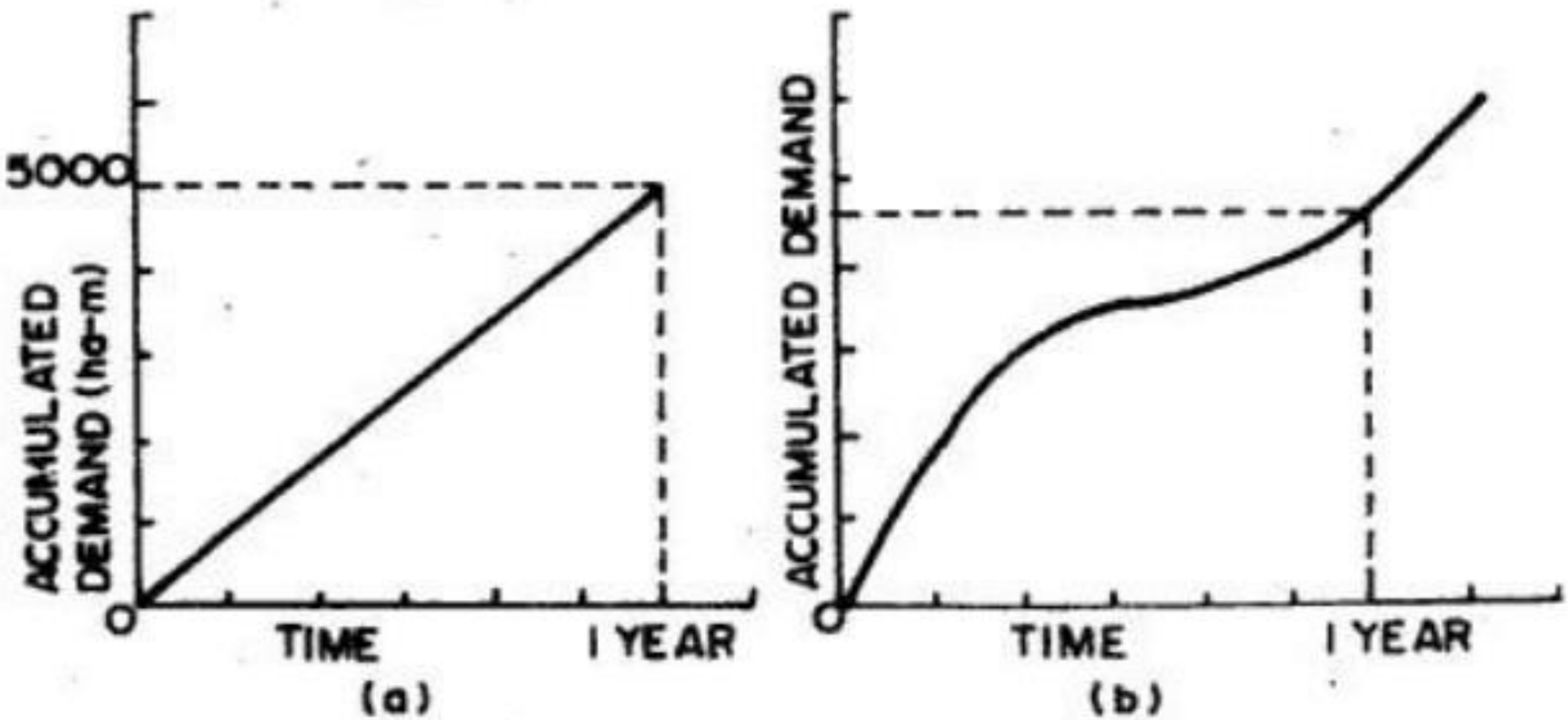


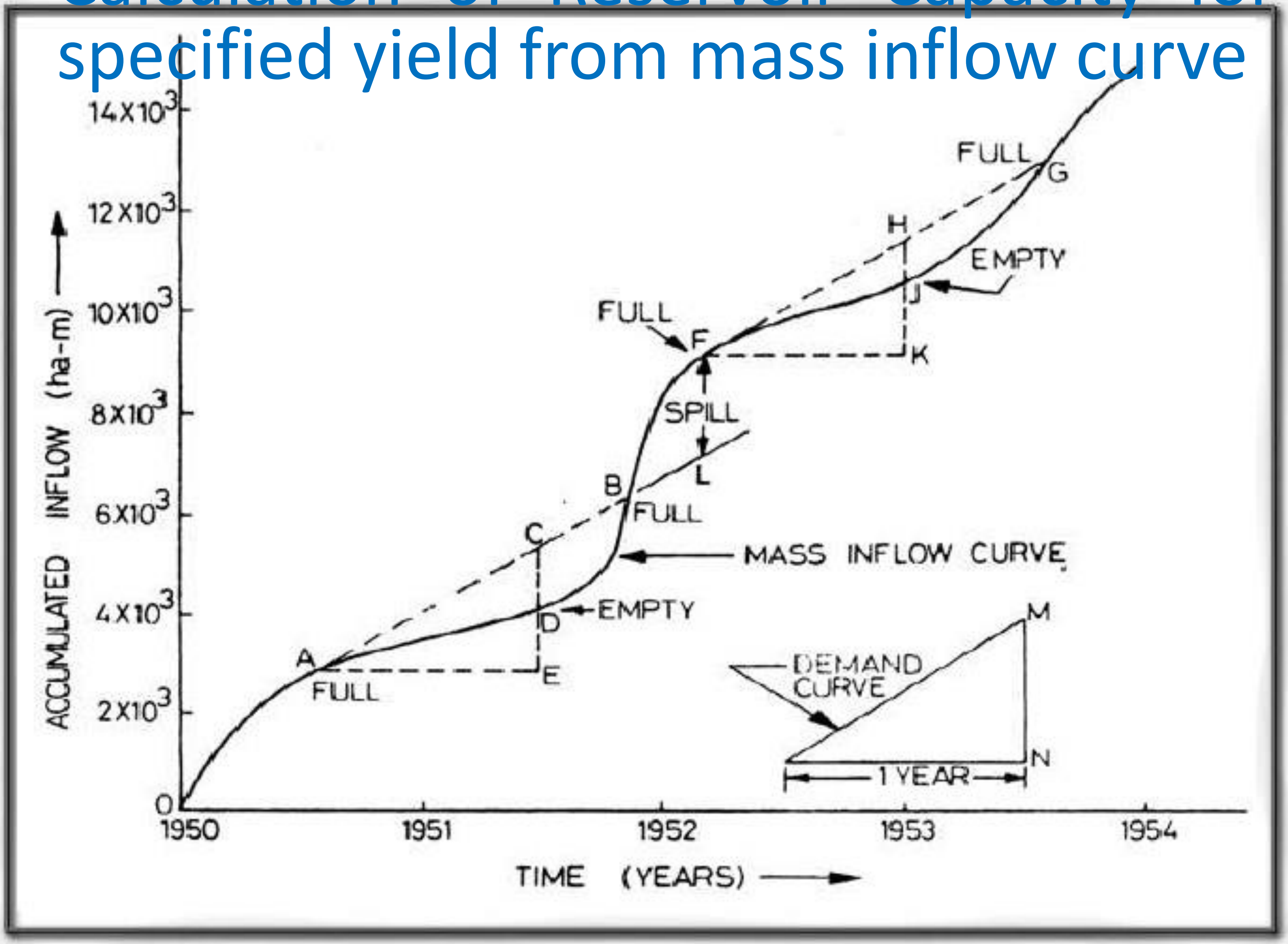
Fig. 9.4. *Flood hydrograph and mass inflow curve.*

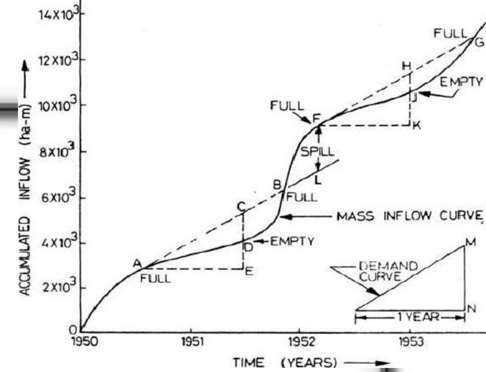
Demand Curve

It is a plot between accumulated demand with time. Uniform demand leads to a straight line. Demand curve indicates variable demand rate over a time.



Calculation of Reservoir Capacity for specified yield from mass inflow curve





3. Draw the lines *AB, FG, etc. such that*

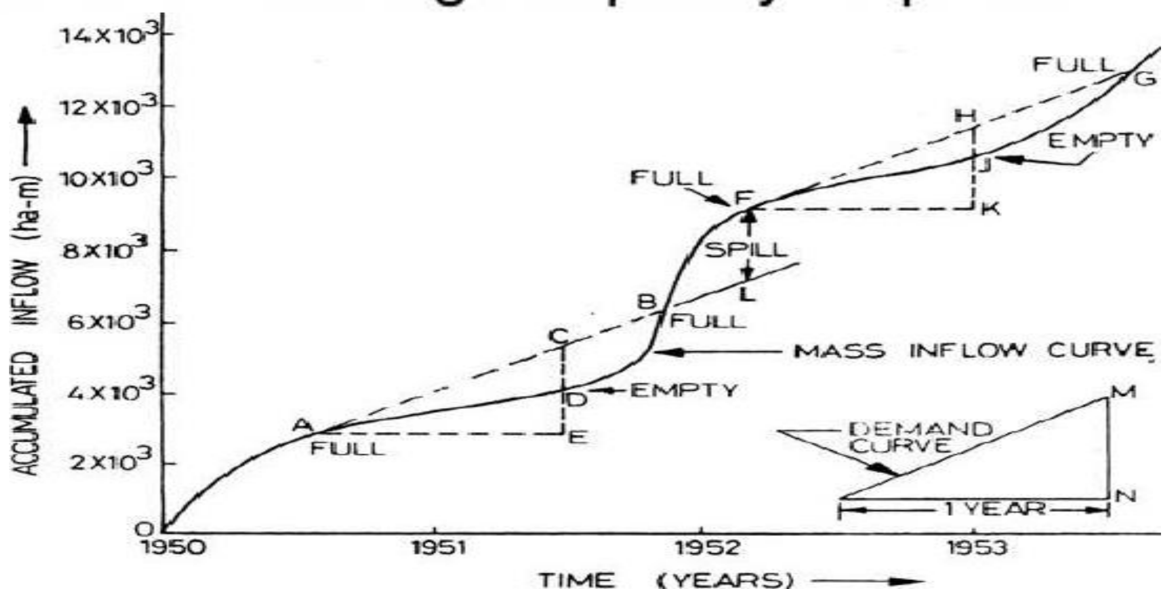
(i) They are parallel to the mass demand curve, and

(ii) They are tangential to the crests A, F, etc. of the mass curve.

4. Determine the vertical intercepts CD. HJ, etc. between the tangential lines and the mass inflow curve. These intercepts indicate the volumes by which the inflow volumes fall short of demand.

Assuming that the reservoir is full at point A, the inflow volume during the period AE is equal to ordinate DE and the demand is equal to ordinate CE. Thus the storage required is equal to the volume indicated by the intercept CD.

5. Determine the largest of the vertical intercepts found in Step (4). The largest vertical intercept represents the storage capacity required.



- The following points should be noted.

  (i) The capacity obtained in the net storage capacity which must be available to meet the demand. The gross capacity of the reservoir will be more than the net storage capacity. It is obtained by adding the evaporation and seepage losses to the net storage capacity.

(ii) The tangential lines AB, FG; etc. when extended forward must intersect the curve. This is necessary for the reservoir to become full again, If these lines do not intersect the mass curve, the reservoir will not be filled again. However, very large reservoirs sometimes do not get refilled every year. In that case, they may become full after 2-3 years.

(iii) The vertical distance such as FL between the successive tangents represents the volume of water spilled over the spillway of the dam.

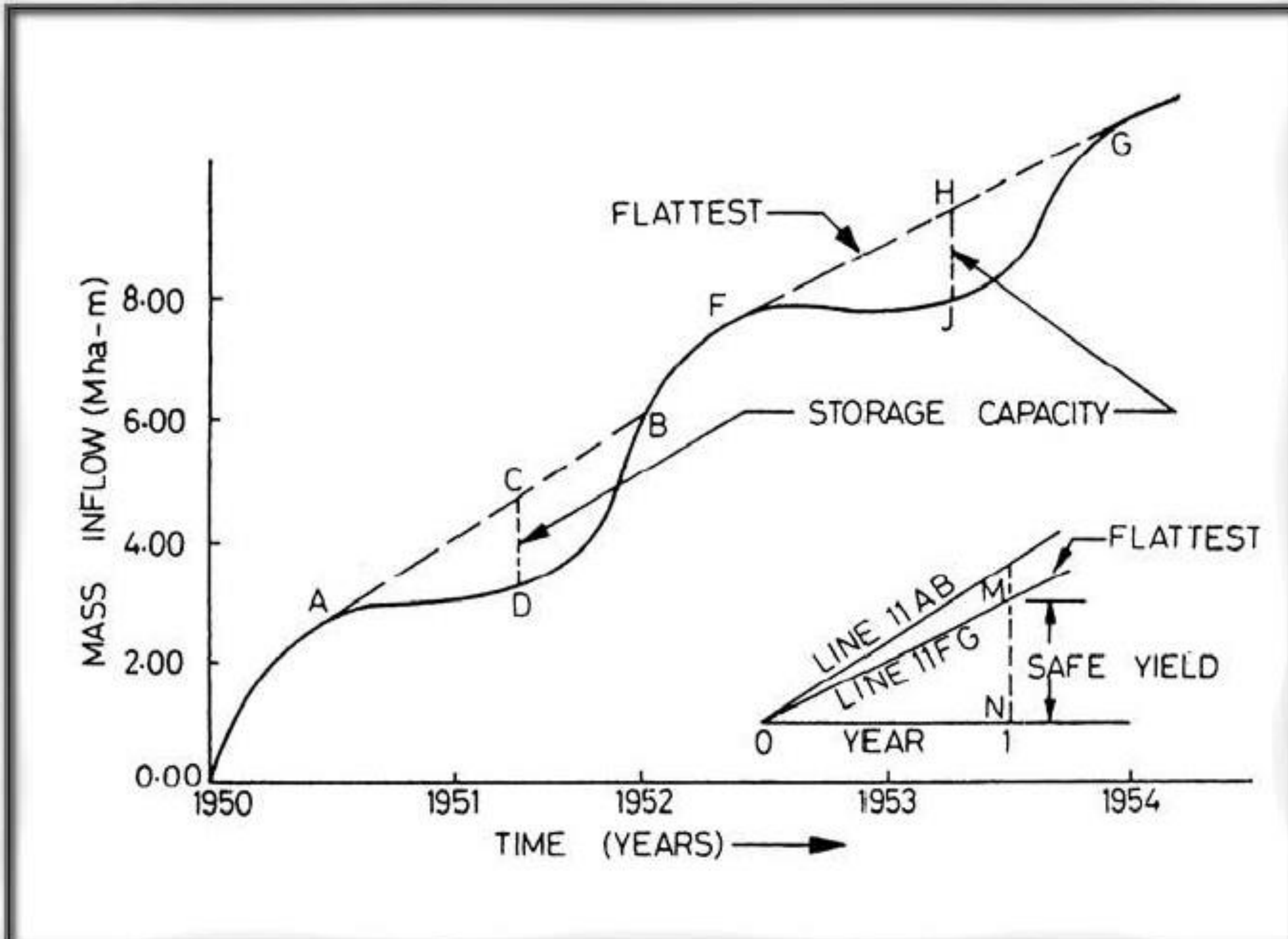
Determination of safe yield from Reservoir of a given

Determination of Yield of a Reservoir

- The yield from a reservoir of a given capacity can be determined by the use of the mass inflow curve

1. Prepare the mass inflow curve from the flow hydrograph of the river.

2. Draw tangents AB, FG, etc. at the crests A, F, etc. of the mass inflow curve in such a way that the maximum departure (intercept) of these tangents from the mass inflow curve is equal to the given reservoir capacity.



FLATTEST
H
G
F
J
B
STORAGE CAPACITY
C
D
A
FLATTEST
LINE 11 AB
LINE 11 FG
M
N
SAFE YIELD
0
YEAR
1
MASS INFLOW (Mha-m)
8.00
6.00
4.00
2.00
0.00
1950
1951
1952
1953
1954
TIME (YEARS)

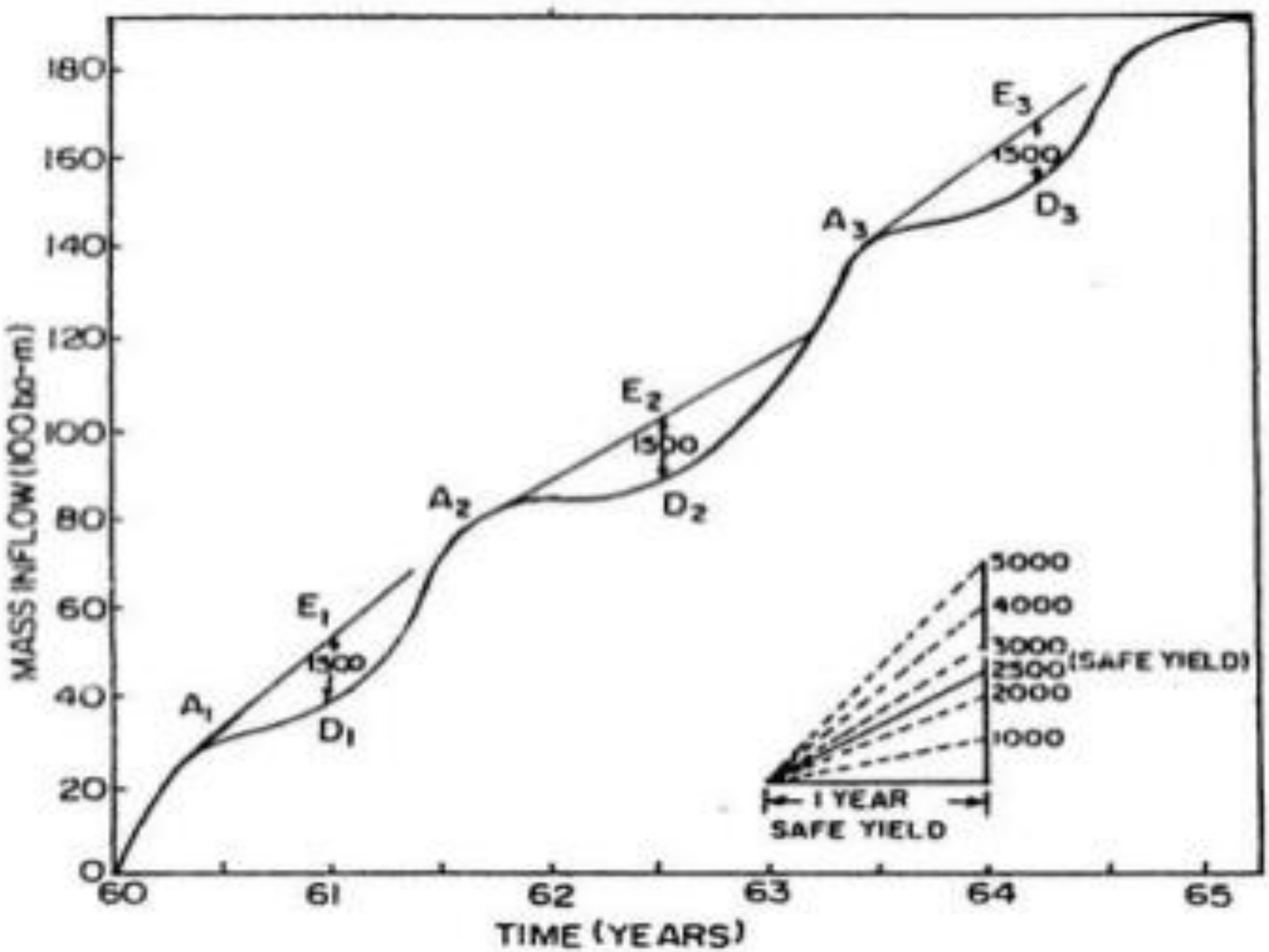


FIG. 6.9 DETERMINATION OF YIELD FROM RESERVOIR OF SPECIFIED CAPACITY

3. Measure the slopes of all the tangents drawn in Step 2.

4. Determine the slope of the flattest tangent.

5. Draw the mass demand curve from the slope of the flattest tangent (see insect). The yield is equal to the slope of this line

Reservoir Sedimentation

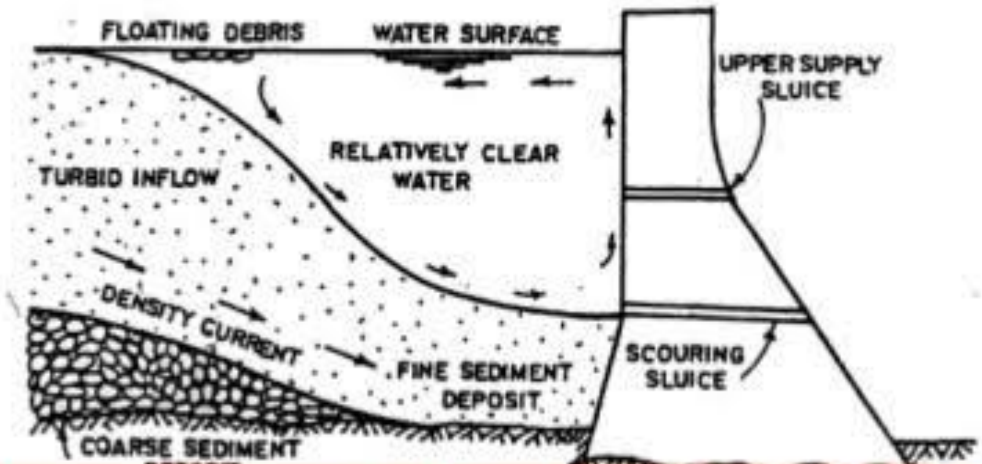
River catchments carry silt during heavy rains.

Factors affecting erosion and silt load are

If a catchment area has sufficient vegetation cover the higher velocities are checked and erosion is very much reduced.

Density currents:-

- Density current may be defined as a flow of one fluid under another fluid of a slightly different density under the effect of gravity.
- In may reservoir density current are usually developed, especially during flood when rivers carry heavily sediment- laden or muddy water.



Density Current is gravity flow of a fluid under another fluid.

- Clear water is in upper layer
- Muddy or turbid water flows along the channel bottom towards dam.

Causes of sedimentation:

- Nature of soil in catchment area
- Topography of the catchment area
- Cultivation in catchment area
- Vegetation cover in catchment area
- Intensity of rainfall in catchment area

- Maximum efforts should water should be released so that less sediments should retain in reservoir.
- Following options are:
  - Catchment vegetation
  - Construction of coffer dams(a watertight enclosure pumped dry to permit construction work below the waterline)/low height barriers
  - Flushing and desilting of sediments
  - Low level outlets / sediment sluicing (sliding gate)

RESERVOIR SEDIMENT TRAP EFFICIENCY

- Reservoir sedimentation depends upon the trap efficiency which decides the amount of sediments deposited with in the reservoir.
- It is the ratio of sediments retained in the reservoir to the sediment inflow to the reservoir.
- Also depends upon fall velocity of various sediments particles flow rate and velocity through the reservoir as well as size, depth, and shape.
- Water viscosity also plays an important role.
- Viscosity of water varies with its chemical composition and composition of sediments.

Measurement of sediment load – sediment sample to be collected at regular intervals of ime and at different depths of the reservoir. The sample are to be dried and the amount of sediment material is calculated. It is calculated as ppm or weight percentage.

Resevoir life – It is dependent on the maintenance of the reservoir and the amount of siltattion taking place at every flood season. A dead storage in the reservoir is provided for silting the fine materials. The water in the dead storage is unutilized. If proper care is not taken in the maintenance of the reservoir i.e ., desilting then the effective storage or live storage will be affected leading to failure of the reservoir or reducing the effective or live storage of the reservoir.

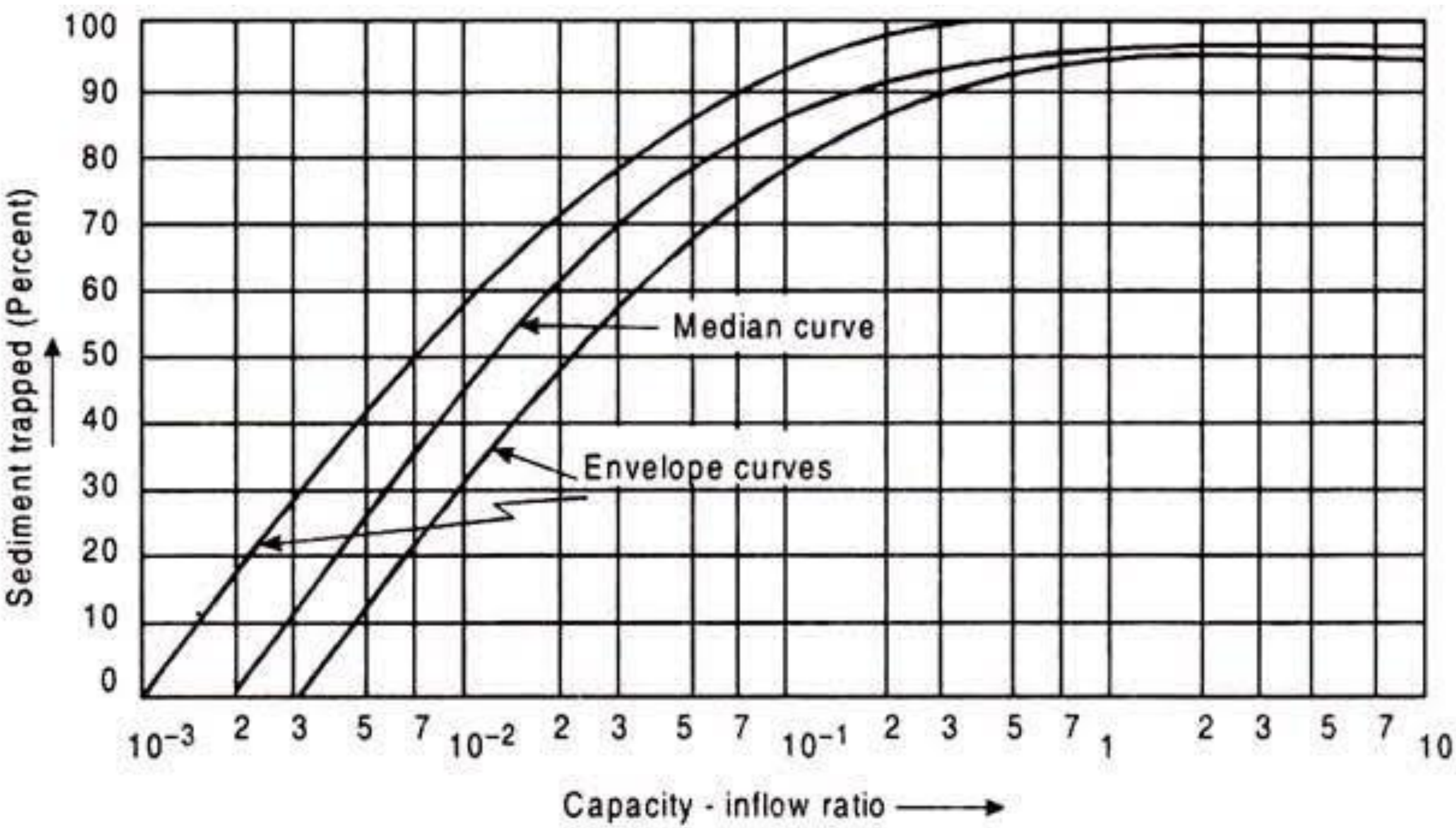
Trap efficiency (η) – This is a measure of reservoir sedimentation.

The investigations show that the trap efficiency is a function of the ratio of reservoir capacity to the total inflow

$$\eta = f\left(\frac{Capacity}{Inflow}\right)$$

The rate of silting is much higher in the initial stages of the inflow into the reservoir, then the rate of silting will reduces as silting goes on. Therefore the complete filling of reservoir may take quite a long period.

with regards to the small reservoir on a large stream



9 *Plot of reservoir-trap efficiency versus capacity-inflow ratio*

Procedure for calculation reservoir life:

- Knowing the inflow rate calculate the (capacity/inflow) ratio and obtain the trap efficiency from the curve.

- Divide the total capacity into any suitable interval, say 10%. Assuming the 10% capacity has been reduced due to sediment deposit, find the trap efficiency for reduced capacity (i.e. 90% of the original) and the inflow ratio.

- For this interval of 10% capacity, find the average trap efficiency by taking average if η found in step 2 and 3.

- Determine the sediment inflow rate by taking water samples and drying the sediment.
- Multiply the total annual sediment transported by the trap efficiency found in step 3.
- Divide the volume interval by the sediment deposited to get the number of years to fill this volume interval of 10% capacity.

- Repeat the procedure for further intervals of the capacity.

- The total life of the reservoir will be equal to the total number of years required to fill each of the volume intervals.