RESERVOIR PLANNING AND MANAGEMENT

Definition:

When a barrier is constructed across some river in the form of dam, water gets stored on the upstream side of a barrier, forming a pool of water, generally called a dam reservoir an impounding reservoir or a river reservoir.

Storage reservoir serve the following purpose:

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

Investigations for reservoir planning

A proper investigation has to be done for reservoir planning. The steps to be followed are

1. Engineering Surveys
2. Geological Investigation
3. Hydrological investigation

Engineering Surveys

In this survey, area of the site (dam site, reservoir and associated works) aresurveyed 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.

Geological Investigation

Geological investigations are required to determine the suitability of foundation for dam, water tightness of the reservoir basin and the location of quarry sites for obtaining suitable construction materials.

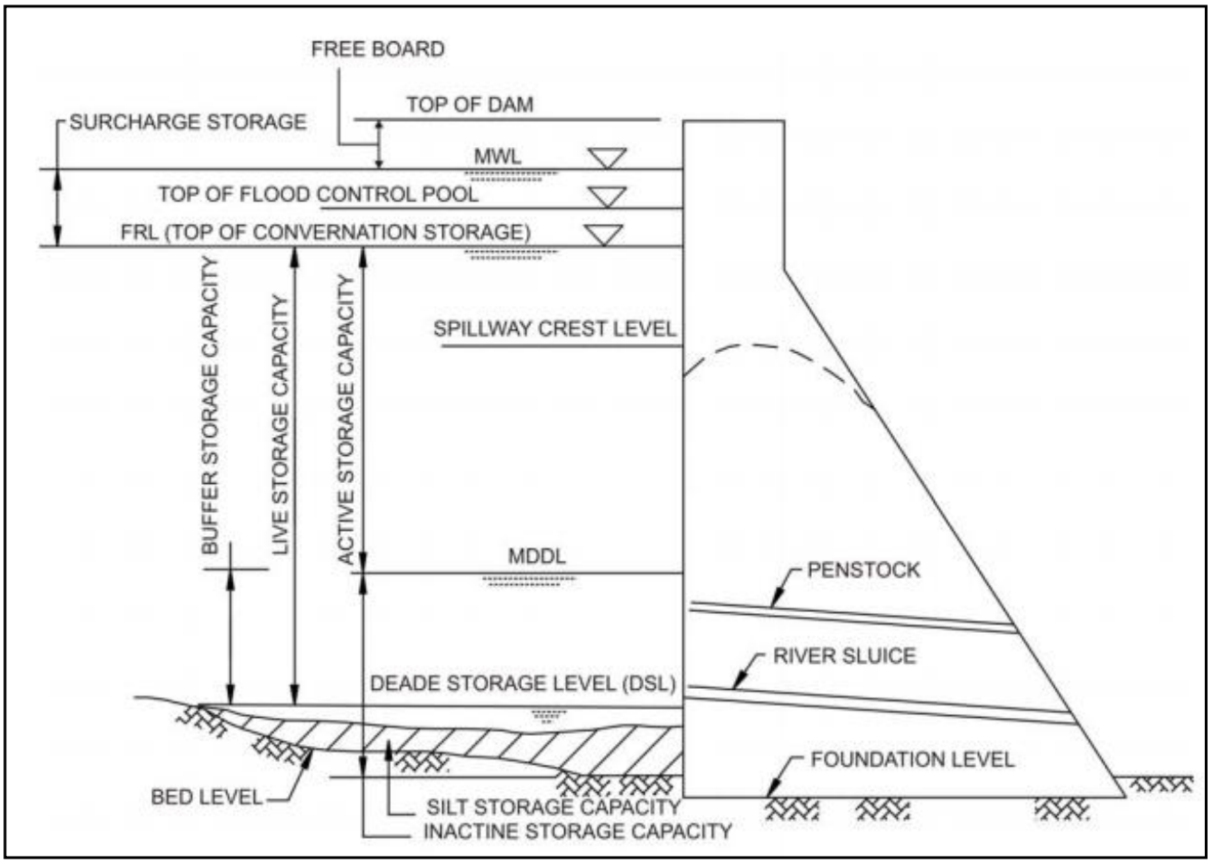
Hydrological Investigation

This is done 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.

Zones of Storage in a reservoir

The storage capacity in the reservoir is divided into three or four parts.



- **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 drawdown level (MDDL):** It is the level below which the reservoir will not be able to drawdown so as to maintain a minimum head required in power projects.
- **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.

The reservoir may be a **single purpose conservation reservoir** or a **single purpose flood control reservoir** or a **Multipurpose reservoir** serving all purpose in a balanced way.

Yield is the volume of water which can be withdrawn from a reservoir in a specified period of time.

Safe yield is the maximum quantity of water which can be supplied from a reservoir in a specified period of time during a critical dry year.

Secondaryyield is the quantity of water which is available during the period of high flow in the rivers when the yield is more than the safe yield.

Averageyield is the arithmetic average of the firm yield and the secondary yield over a long period of time.

Designyield is the yield adopted in the design of a reservoir. The design yield is usually fixed after considering the urgency of the water needs and the amount of risk involved.

Reservoir Capacity depends upon the inflow available and demand.

- If the inflow in the river is always greater than the demand, there is no storage required
- If the inflow in the river is small but the demand is high, a large reservoir capacity is required

The required capacity for a reservoir can be determined by the following methods:

1. Graphical method, using mass curves.
2. Analytical method

Determination of reservoir capacity for a specified yield or demand using mass curve

1. Prepare a mass inflow curve from the flow hydrograph of the site for a number of consecutive years including the most critical years (or the driest years) when the discharge is low.

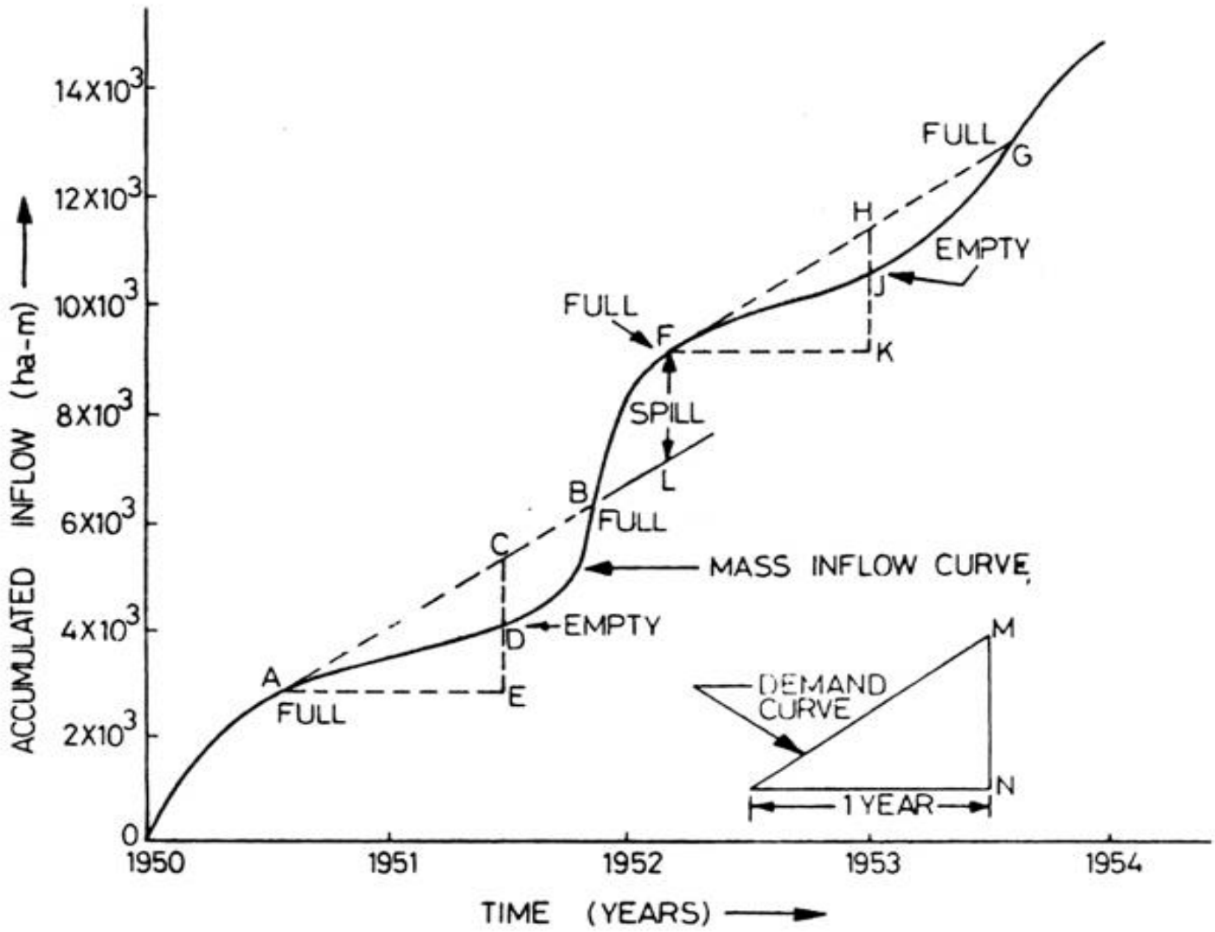
2. Prepare the mass demand curve corresponding to the given rate of demand. If the rate of demand is constant, the mass demand curve is a straight line. The scale of the mass demand curve should be the same as that of the mass inflow curve.

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.

Analytical Method

In the analytical method, capacity of the reservoir is determined from the net inflow and demand.Storage is required when the demand exceeds the net inflow. The total storage required is equal to the sum of the storage required during the various periods.

1. Collect the stream flow data at the reservoir site during the critical dry period. Generally, the monthly inflow rates are required. However, for very large reservoirs, the annual inflow rates may be used.

2. Ascertain the discharge to be released downstream to satisfy water rights or to honour the agreement between the states or the cities.

3. Determine the direct precipitation volume falling on the reservoir during the month.

4. Estimate the evaporation losses which would occur from the reservoir. The panevaporation data are normally used for the estimation of evaporation losses during the month.

5. Ascertain the demand during various months.

6. Determine the adjusted inflow during different months as follows:

Adjusted inflow = Stream inflow + Precipitation - Evaporation – Downstream Discharge

7. Compute the storage capacity for each months.

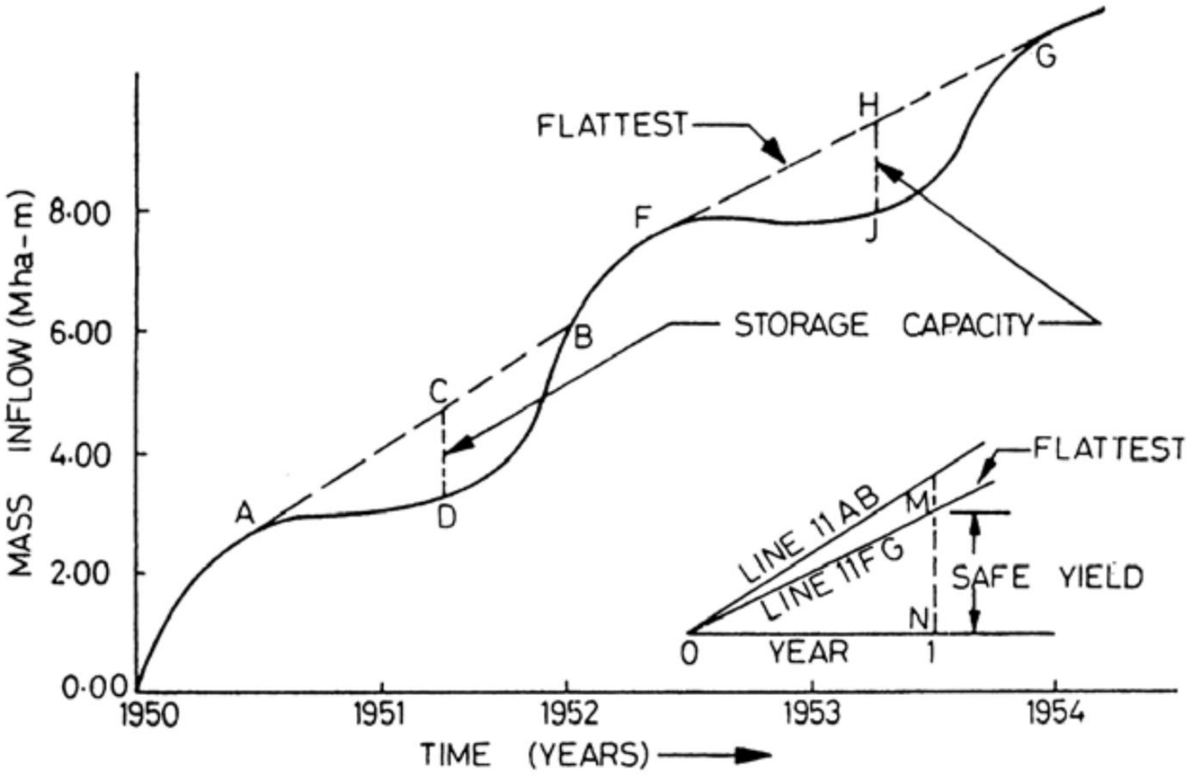
Storage required = Adjusted inflow – Demand

8. Determine the total storage capacity of the reservoir by adding the storages required found in Step 7.

Determination of Yield from 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.
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:

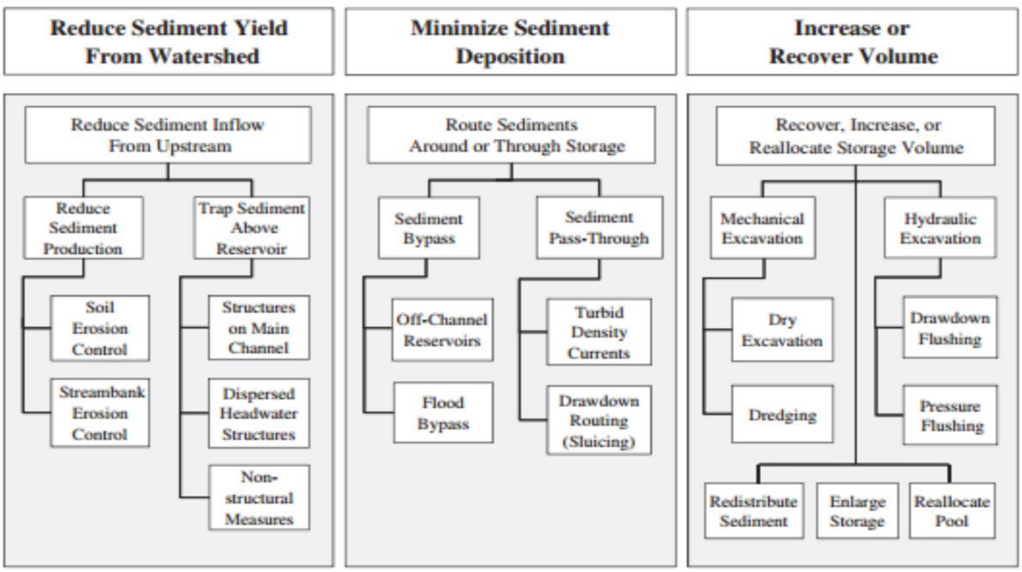
It is a difficult problem for which an economical solution has not yet been discovered, except by providing a "dead storage" to accommodate the deposits during the life of the dam. Disintegration, erosion, transportation and sedimentation are the different stages leading to silting of reservoir.

The different causes of sedimentation in catchment area are nature of soil in catchment area, topography of the catchment area, cultivation in catchment area, vegetation cover in catchment area and intensity of rainfall in catchment area.

Maximum efforts should be taken to manage sedimentation. Water should be released so that less sediments should retain in reservoir. Following options are:

- Catchment Vegetation
- Construction of coffer dams/low height barriers
- Flushing and desilting of sediments
- Low level outlets / sediment sluicing
- **Excavation** A method to remove soil-storing area in reservoir by heavy
- **Dredging** A method to remove sediments settled under water by dredger
- **Check dam (+excavation work)** Construction of check dam on the river and to remove sediments stored at the check dam by heavy machine
- **Flushing Sediments** flushing by temporarily lowering water level of reservoir
- **Construction of bypass tunnel** Sediments are diverted directly downriver through the bypass tunnel
- **Dry excavation** to create a greater depth of water Periodical reservoir emptying to excavate and remove sediments under water

- Reduced Sediment Loads Downstream of Dams



FLOOD

A “flood” may be defined as a great flow of water, but usually a flood is consider to be an unusually high stage of a river at which a stream channel becomes filled and above which it overflows its banks and floods near by land. Thus whenever an overflows through the banks it is said to be flooded

The maximum flood that any structure can safely pass is called the “Design Flood” and is selected after consideration of economic and hydrologic factors.

A flood is an unusual high stage of a river overflowing its banks and inundation the marginal lands. This is due to severe storm of unusual meteorological combination, sometimes combined with melting of accumulated snow on the catchment .This may also be due to shifting of the course of the river, earthquake causing bank erosion, or blocking of river, or beaching of the river flood banks.

Floods cause much loss of life and property,disruption of communication, damage to crops, famine, epidemic diseases and other indirect losses.

Various methods adopted for flood control can be classified into 3 categories:

- ❑ Method adopted to modify the flood
- ❑ Method adopted to modify the susceptibility of flood
- ❑ Method adopted to reduce the losses

1) Method adopted to modify the flood

- **Control measures for channel phase**
  - ***Construction of Reservoirs***
  - ***Improvement of river channels***
  - ***Construction of levees and flood walls***
  - ***Diversion of flood water to flood ways***
  - ***Use of natural detention basin***
  - Construction of emergency flood ways
  - Adoption of inter basin transfer
  - Bank stabilization
  - Construction of ring bunds, and
  - Development of underground storage.

- **Flood control measures for land phase**
    - Watershed management,
    - Engineering measures for flood abutment,
    - Agronomic measures for flood abutment, and
    - Afforestation.
- **Atmospheric phase** - Weather modification

2) Methods adopted to modify susceptibility of flood damage

- ***Flood plain management***
- Adoption of suitable development policies
- Effective structural changes
- Flood proofing areas
- Disaster preparedness and response for plan
- ***Flood forecasting and flood warning***
- Susceptibility of flood damage

3) Methods to reduce the losses

- Emergency evacuation
- ***Flood fighting***
- Adopting suitable public health measures
- Providing disaster relief
- Tax remission

The objective of the flood control is to reduce or to alleviate the negative consequences of flooding .Alternative measures that modify the flood runoff are usually referred to as flood control facilities and consist of engineering structures or modifications .Construction of flood control facilities referred to as ***structural***

measures are usually designed to consider the flood characteristics including ***reservoirs, diversions, levees or dikes, and channel modifications***. Flood control measures that modify the damage susceptibility of floodplains are usually referred to as nonstructural measures and may require minor engineering works. ***Nonstructural measures*** are designed to modify the damage potential for permanent facilities and provide for reducing potential damage during a flood event. Nonstructural measures include ***flood proofing, flood warning, and land-use controls.***

REFERENCES AND FURTHER READING FOR STUDENTS

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