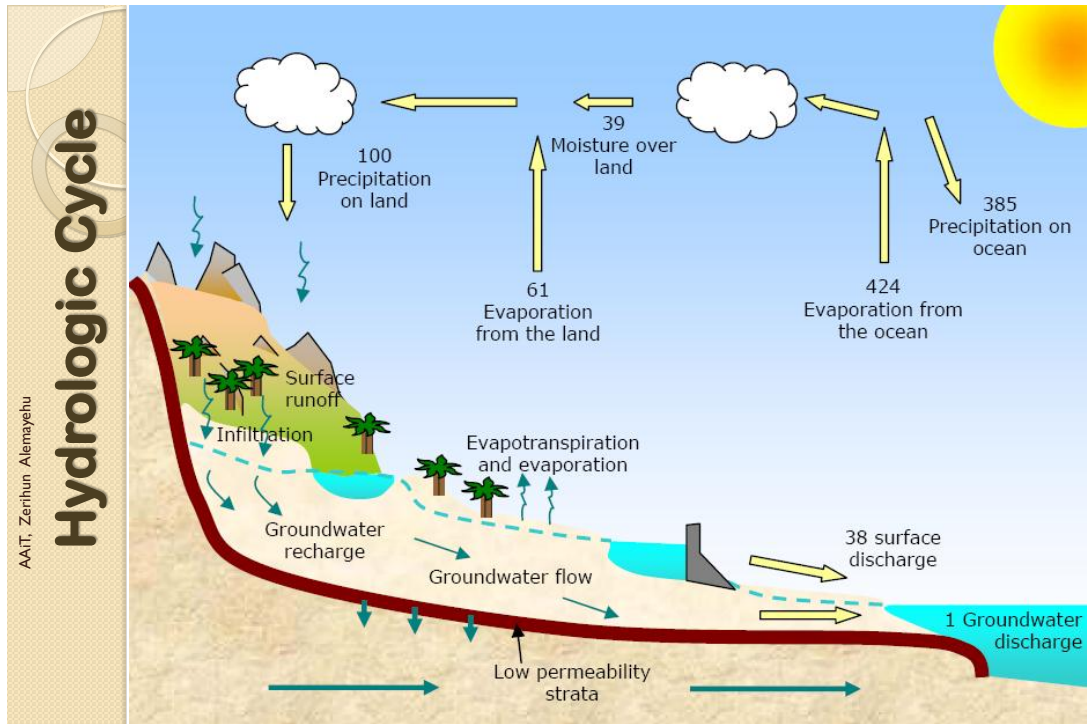


CHAPTER 2

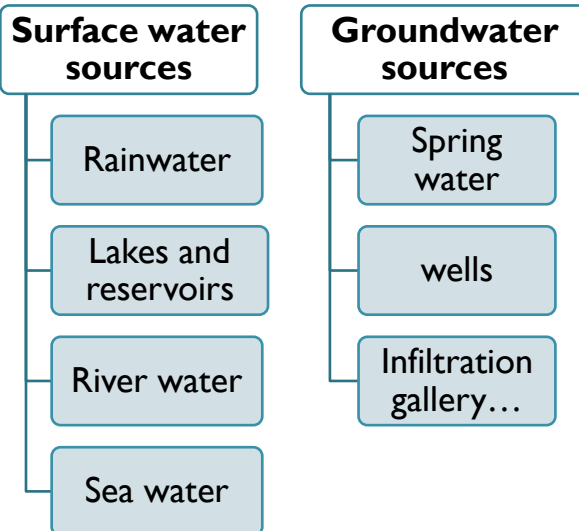
Sources of Water Supply

Introduction

- Nature of **water source** determines the components of the **water supply system**
- Factors to be considered to select source:
 - Quantity
 - Quality
 - Reliability
 - Safety of source
 - Water rights
 - Environmental impacts...



Types of water supply sources



Rain water

- Rain water might contain dust, smoke, bacteria, carbon dioxide... as falling from high altitude
- RW Harvesting- roofs are most effective and can be integrated with tanks



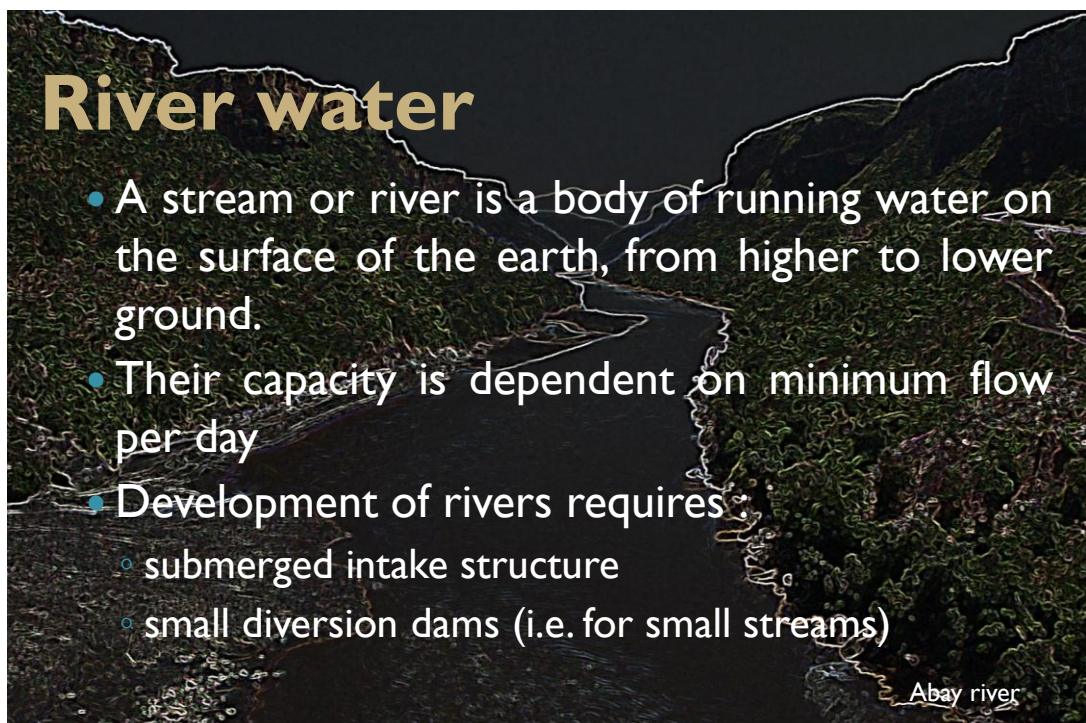
Rain water...

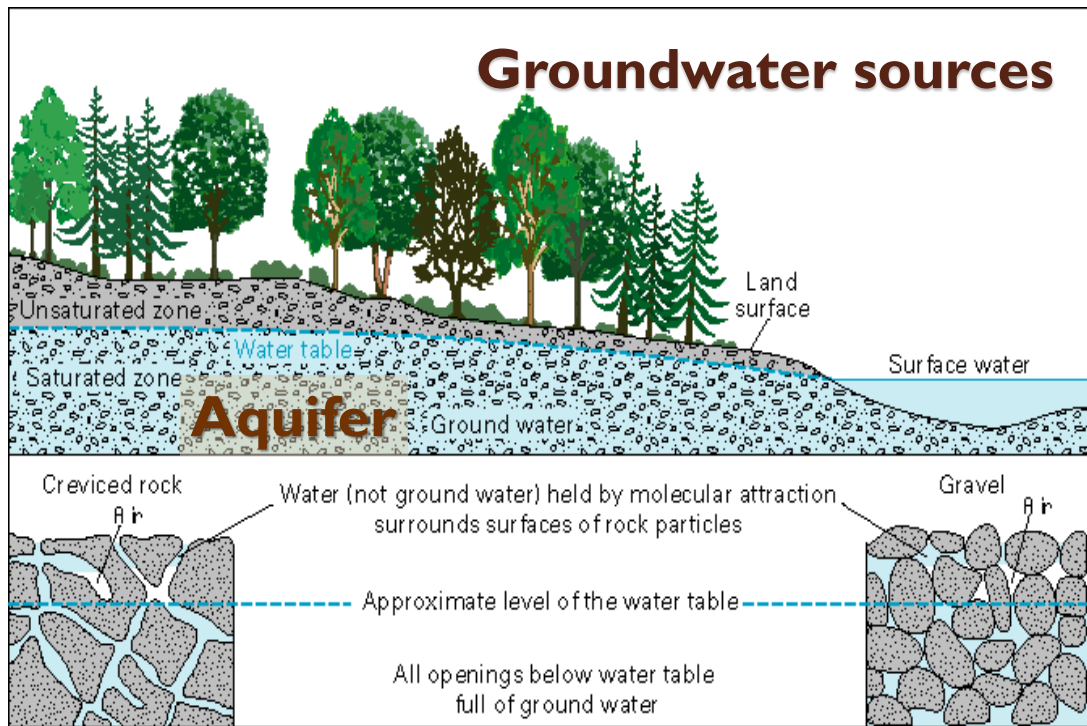
- Advantages of rainwater collection:
 - Quality of RW is high
 - Independent
 - Local materials can be used for collection
 - No energy costs
 - Easy to maintain
 - Time saving and convenient
- Disadvantages
 - High initial cost (i.e. for a family)
 - Quantity of water is dependent on the roof area and rainy seasons
 - Flat taste

Lakes and reservoirs

- Store water in wet seasons for usage in dry seasons
- It is a standing water; because of this:
 - Quality is very low: turbidity, bacteria and pollutants
 - Thermal stratification (i.e. for deep lakes/reservoirs)

Lake Tana





Groundwater sources

• **Advantages :**

- It is likely to be free of pathogenic bacteria
- free from turbidity and colour
- It can be used without further treatment
- It can be found in the close vicinity
- It is economical to obtain and distribute
- The water-bearing stratum provides a natural storage at the point of intake.

Groundwater sources...

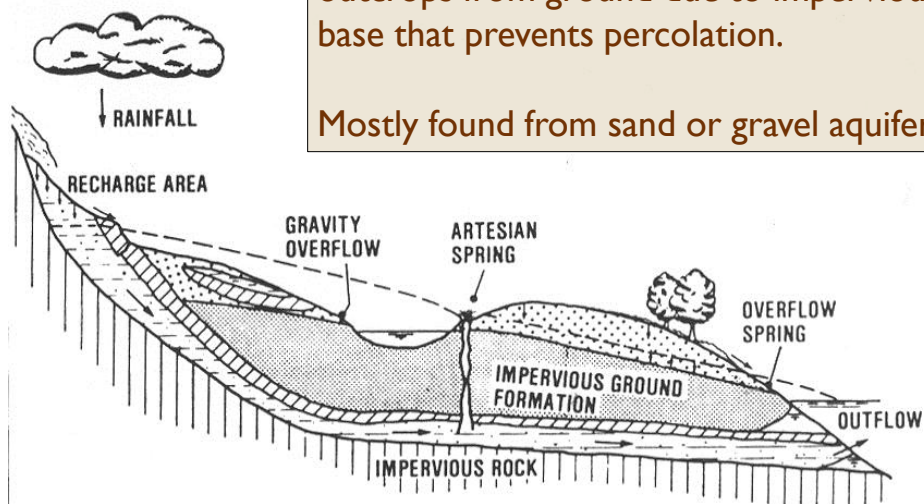
- **Disadvantages**
 - often have high in mineral content;
 - It usually requires pumping.
- **CATIONS:** calcium, magnesium, iron and manganese
- **ANIONS:** bicarbonate, carbonate, and chloride

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Springs

Spring water is a groundwater that outcrops from ground due to impervious base that prevents percolation.

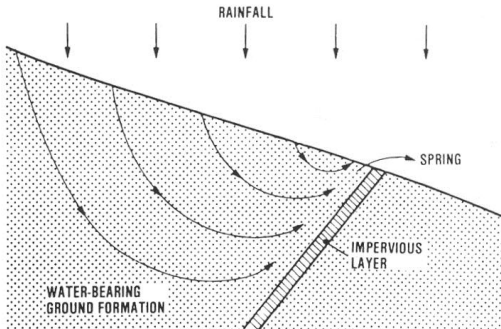
Mostly found from sand or gravel aquifers



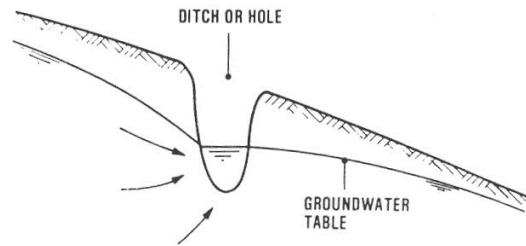
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• Gravity springs

- GW flows over an impervious stratum onto the ground surface
- The yield varies with the position of the water table
- May dry up during or immediately after a dry season



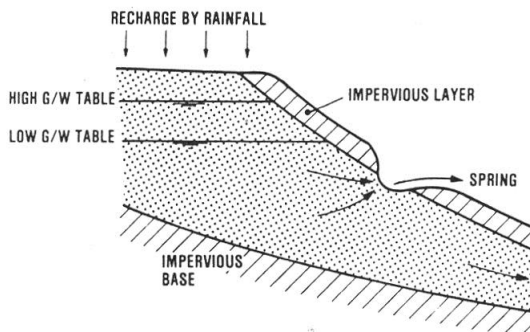
Gravity overflow spring



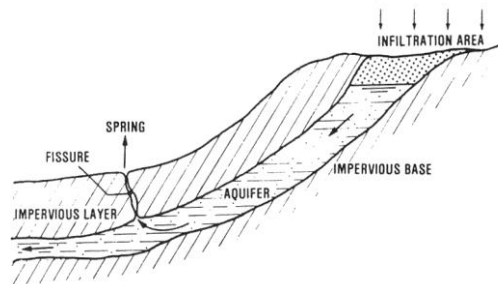
Gravity depression spring

• Artesian springs

- High quality water due to confinement
- High discharge due to high pressure in the confinement
- Yield is likely uniform and nearly constant over the seasons of the year



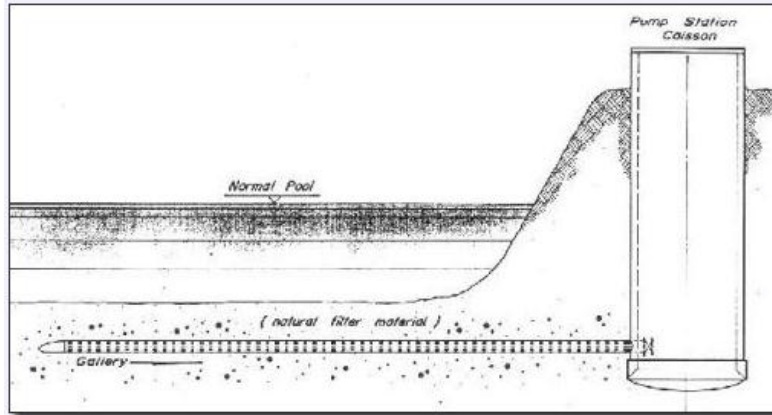
Artesian depression spring



Artesian fissure spring

Infiltration gallery

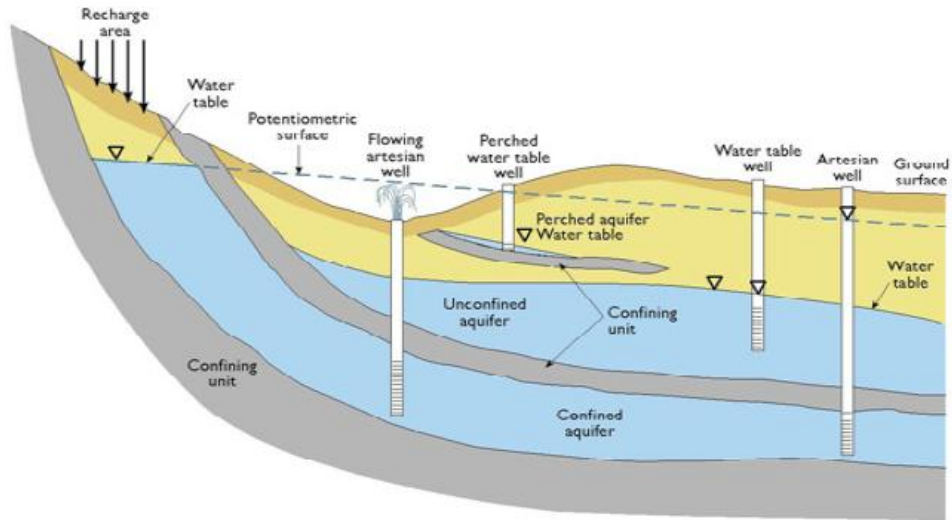
- Horizontal wells that collect water over practically their entire lengths.
- Simple means of obtaining naturally filtered water



Recharge of aquifers

- Replenishment (filling) of aquifers is known as **recharge**
 - Unconfined aquifers are recharged by precipitation percolating down from the land's surface
 - Confined aquifers are generally recharged where the aquifer materials are exposed at the land's surface - called an **outcrop**.

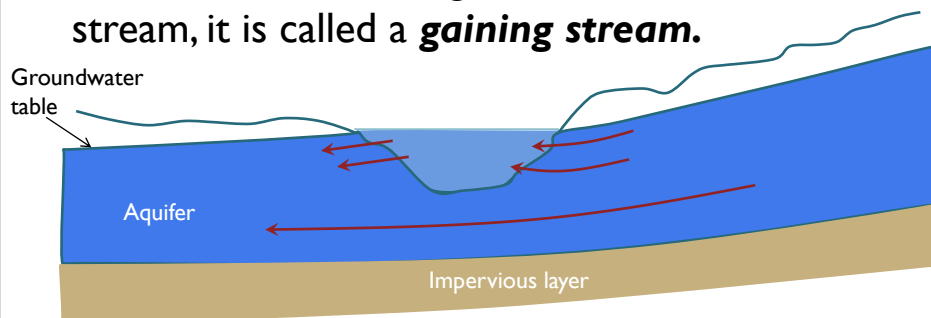
Recharge of aquifers



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Recharge of aquifers...

- When surface water loses water to the adjacent aquifer, the stream is called a **losing stream**.
- water flows from the ground water to the stream, it is called a **gaining stream**.



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Water quality considerations

- To evaluate and classify raw water quality
 - physical, chemical, and bacteriological parameters
- To identify sources of pollution
 - *Surface water*: urban runoff, agricultural runoff, industrial discharge, and leachate from landfills;
 - *Groundwater*: infiltration from pit-latrines and septic tanks, landfill leachate, and infiltration from polluted areas.
- To assess the treatment required for beneficial uses
 - level of treatment and unit process required are dependent on the raw water quality

Treatment types

For groundwater having excellent quality



For groundwater having moderate quality

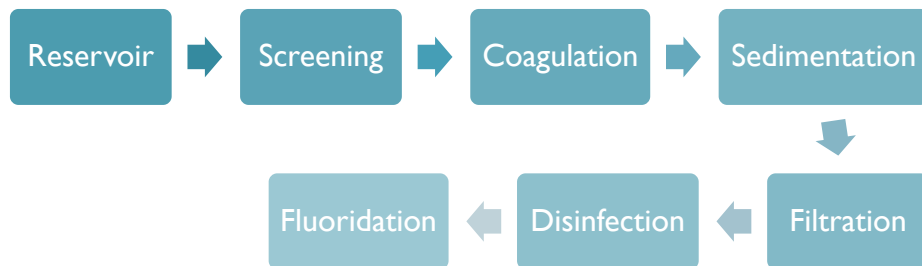


Treatment types

Good quality upland reservoir



Moderate to poor quality lowland river



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Source selection

• Surface water sources

- Safe water yield during the drought years
- Urbanization and land development in the watershed
- Proposed impoundments on tributaries
- Water quality
- Assessment of reliability
- Requirements for construction of water supply system components
- Economics of the project
- Environmental impacts of the project
- Water rights

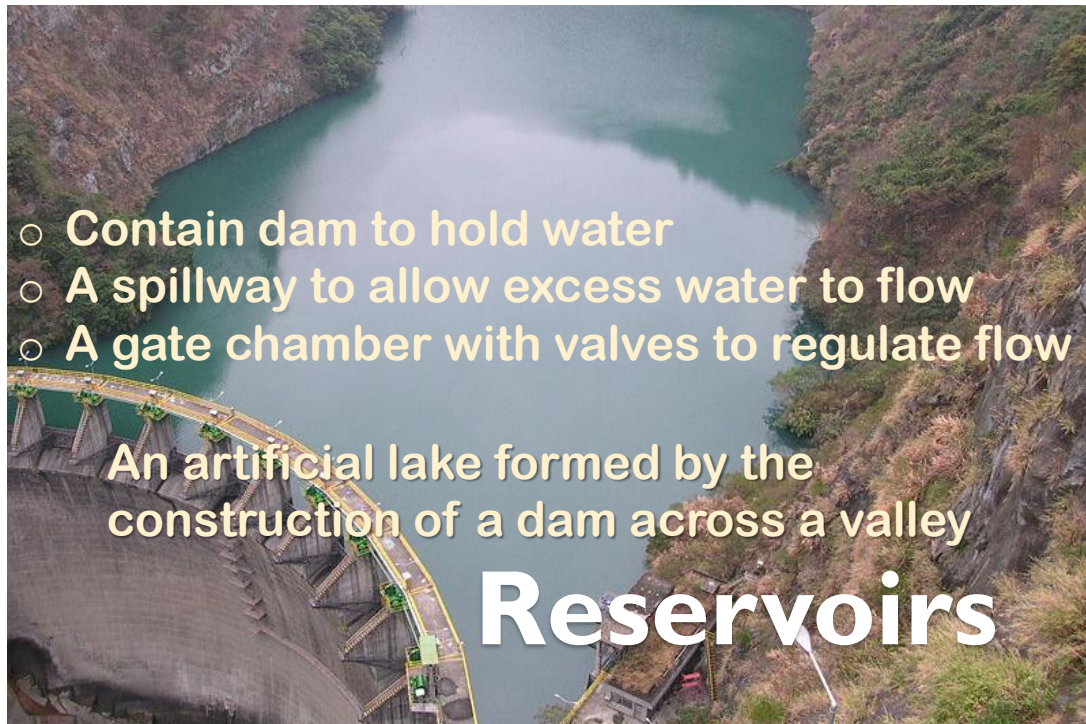
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Source selection...

- **Ground water sources**

- Aquifer characteristics (depth, geology,
- Safe aquifer yield
- Permissible drawdown
- Water quality
- Source of contamination (gasoline, oil, chemicals)
- Saltwater intrusion (areas near to seas or oceans)
- Type and extent of recharge area
- Rate of recharge
- Water rights

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Reservoirs

- The area of land draining to the dam site is called a catchment or watershed.



Reservoirs

Investigations for reservoir planning:

- **A. Topographic surveying-** to produce a topo-map which will be used as a base for
 - preparing water surface area vs. elevation curve
 - plotting storage volume vs. elevation
 - indicating man-made and natural features that may be affected

Reservoirs

- **B. Geologic investigations**
 - Water tightness of the reservoir basin
 - Suitability of foundations for the dam
 - Geological and structural features, such as faults, fissures, etc
 - Type and depth of overburden
 - Location of permeable and soluble rocks if any
 - Ground water conditions in the region
 - Location and quantity of materials for the dam construction

Reservoirs...

- **C. Hydrological investigations**
 - determination of rainfall, runoff, seepage, and evaporation in the reservoir catchment from long years of data.

These information are essential for estimating the **reservoir capacity and design of spill way**.

Selecting reservoir site

- Catchment geology- minimum percolation losses and high runoff potential
- Dam site- strong foundation with minimum seepage loss
- Narrow valley- sites that resulting lesser dam length
- Topography- should be such that large area and valuable properties are not submerged
- Site that creates deep reservoirs- this has the advantages of minimizing the evaporation loss and submerged area when compared to shallow reservoirs
- Sites that ensure good water quality- avoid sites that are downstream of waste discharges and tributaries with high silt loads

Volume of reservoirs

- the **safe yield** from a reservoir > **demand**
- **Safe yield** or firm yield: is the **maximum quantity of water** that can be guaranteed during a critical dry period.
- Methods to determine the storage volume of reservoirs:
 - mass curve method
 - analytical method.

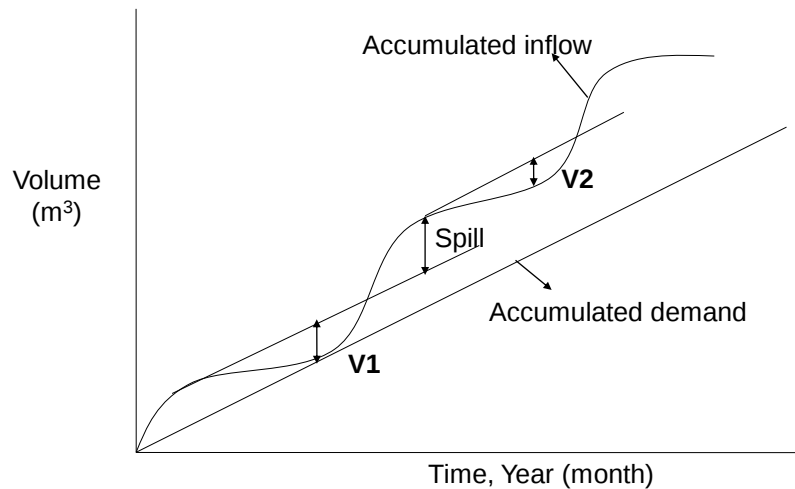
Mass curve method

- reservoir capacity is determined from accumulated mass inflow and accumulated demand curves.
- Net Inflow= total Inflow-outflow (evaporation, seepage, d/s flow)

Procedure

- Prepare accumulated mass inflow curve from the stream hydrograph
- Prepare the accumulated demand curve on the same scale
- Draw tangent lines that are parallel to the accumulated demand curve at the high points of the accumulated mass curve (P_1, P_2, P_3 , etc)
- Measure the vertical distances between the tangent lines and the mass inflow curve (V_1, V_2, V_3 , etc.)
- Determine the required reservoir storage capacity as the **largest of the vertical distances** (V_1, V_2, V_3 , etc.)

Mass curve method



Analytic method

- Calculate the net inflow from the given hydrological data
- Calculate the deficiency (demand – net inflow)
- Compute the cumulative deficiency. If the cumulative deficiency is negative, take the cumulative deficiency as zero
- Determine the required reservoir capacity as the **maximum cumulative deficiency**

(1)	(2)	(3)= (2)-(1)	(4) if CF is -ve, take 0
Net inflow (m^3)	Demand (m^3)	Deficiency (m^3)	Cumulative deficiency (m^3)
I_1	D_1	F_1	$CF_1 = F_1$
I_2	D_2	F_2	$CF_2 = CF_1 + F_2$
I_3	D_3	F_3	$CF_3 = CF_2 + F_3$

Example

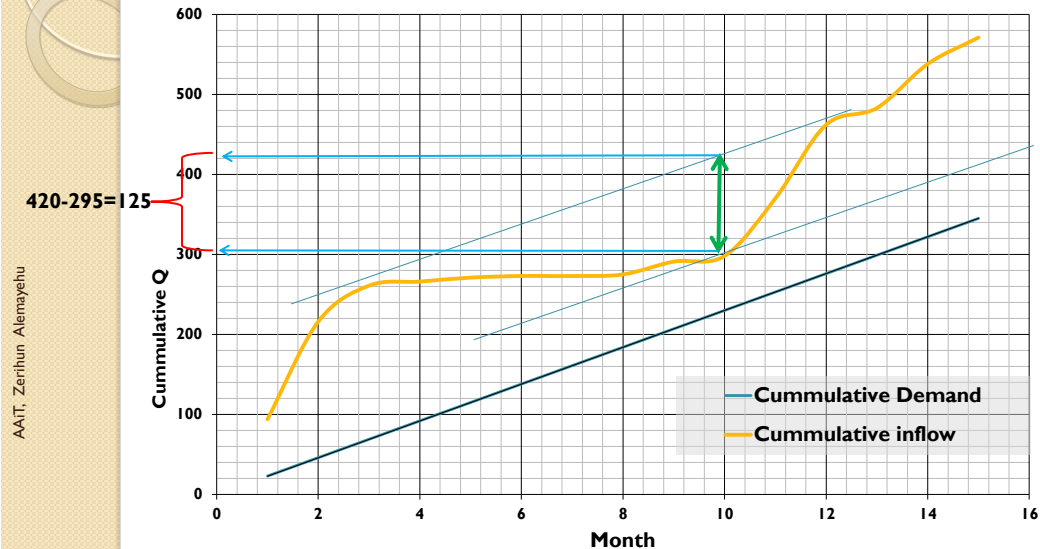
Compute the storage requirement needed for an impounding reservoir for a constant draft of 23 ML/km²/months of 30.4 days with the given monthly net river inflow for a critical year.

Month	Inflow (ML/km ²)
1	94
2	122
3	45
4	5
5	5
6	2
7	0
8	2
9	16
10	7
11	72
12	92
13	21
14	55
15	33

Analytical Solution

Month	inflow	draft/ demand	Cummulative Demand	Cummulative inflow	Dfficiency	cummulative Deficiency	Cummulative surplus
1	94	23	23	94	-71	0	71
2	122	23	46	216	-99	0	170
3	45	23	69	261	-22	0	192
4	5	23	92	266	18	18	0
5	5	23	115	271	18	36	0
6	2	23	138	273	21	57	0
7	0	23	161	273	23	80	0
8	2	23	184	275	21	101	0
9	16	23	207	291	7	108	0
10	7	23	230	298	16	124	0
11	72	23	253	370	-49	75	49
12	92	23	276	462	-69	6	118
13	21	23	299	483	2	8	0
14	55	23	322	538	-32	0	32
15	33	23	345	571	-10	0	42

Graphical Solution



Impoundments

A. Embankment dam- a dam constructed from natural materials

- *Earth fill dam*: compacted soil
- *Rock fill dam*: coarse-grained material or crushed rock with impervious membrane

Advantages:

- For sites in wide valleys and steep-sided gorges
- Adaptability to a broad range of foundation conditions
- Use of locally available natural materials

Disadvantages:

- Easily damaged or destructed by overflow
- leakage and internal erosion

Impoundments...

B. Concrete dam- gravity dam, arch dam, buttress dam, etc.

Gravity dam

- Dependent upon its own mass for stability.
- For gorges with very steep side slopes
- It can be constructed by Masonry(stone or brick)
- Shape: straight or curved
- Dam height: can be very high for sound foundation

Impoundments...

Arch dam

- Functions structurally as a horizontal arch, transmitting the major portion of the water load to the abutments or valley sides rather than to the floor of the valley.
- structurally more efficient, needs less concrete volume

Buttress dam

- consists of a continuous upstream face supported at regular intervals by downstream buttresses.

Catchment protection

- Minimization of diffuse pollution from urban runoff
- Minimization of agricultural diffuse pollution
- Controlling discharges from point sources such as wastewater treatment plant, industries, etc
- Limitation of soil erosion through soil conservation measures, such as afforestation, etc.
- Providing corridors along tributary streams, rivers, and the reservoir