

CHAPTER-4:

CLASSIFICATION AND TYPE OF HYDROPOWER DEVELOPMENT

HWRE3171

CLASSIFICATION AND BASIS

- Hydropower plants could be classified on the basis of
 - The hydraulic features of the plant
 - Operating features of the plant
 - On plant Capacity
 - On operating head
 - On Construction Features
 - Location & topographical features
 - Presence or absence of storage
 - The range of operating heads
- A complete understanding of the type requires information under all such categories
- All the above classification basis are not mutually exclusive.

CLASSIFICATION BASED ON HYDRAULIC FEATURES

- *Conventional Hydro-plants*
 - Use normally available hydraulic energy of the flow of the river.
 - Run-of river plant, diversion plant, storage plant
- *Pumped storage plants*
 - Use the concept of recycling the same water.
 - Normally used with areas with a shortage of water
 - It generates energy for peak load, and at off-peak periods water is pumped back for future use.
 - A pumped storage plant is an economical addition to a system which increases the load factor of other systems and also provides additional capacity to meet the peak load.
- *Unconventional Hydro-plants*
 - Tidal power plant
 - Use the tidal energy of the sea water.
 - Very few have been constructed due to structural complication.
 - Depression power plant
 - Hydropower generated by diverting an ample source of water in the natural depression
 - Water level in the depression is controlled by evaporation

CLASSIFICATION BASED ON ACTUAL OPERATION IN MEETING THE DEMAND:

- isolated plant - operating independently
- interconnected in to grids
- In a grid system, a power station may be distinguished as a **base load plant** or **peak load plant**.
- Hydropower plants are best suited as **peak load plants**, because
- hydropower plants can start relatively quickly and can thus accept load quickly.
- WHY Dam===== (Qpeak),
- Reservoir===== (Qmin)-----???????????

CLASSIFICATION BASED ON PLANT CAPACITY

- Classification based on plant capacity changes with time and according to standards and codes of a country.
- *According to Mossonyi*
 - Midget plant up to 10 KW
 - Low capacity < 1000KW
 - Medium capacity < 10,000KW
 - High capacity > 10,000KW
- According to Present day classification (literatures)
 - Micro hydropower < 5 MW
 - Medium plant 5 to 100 MW
 - High Capacity 100 to 1,000 MW
 - Super plant above 1,000 MW

Ethiopia's Hydropower?

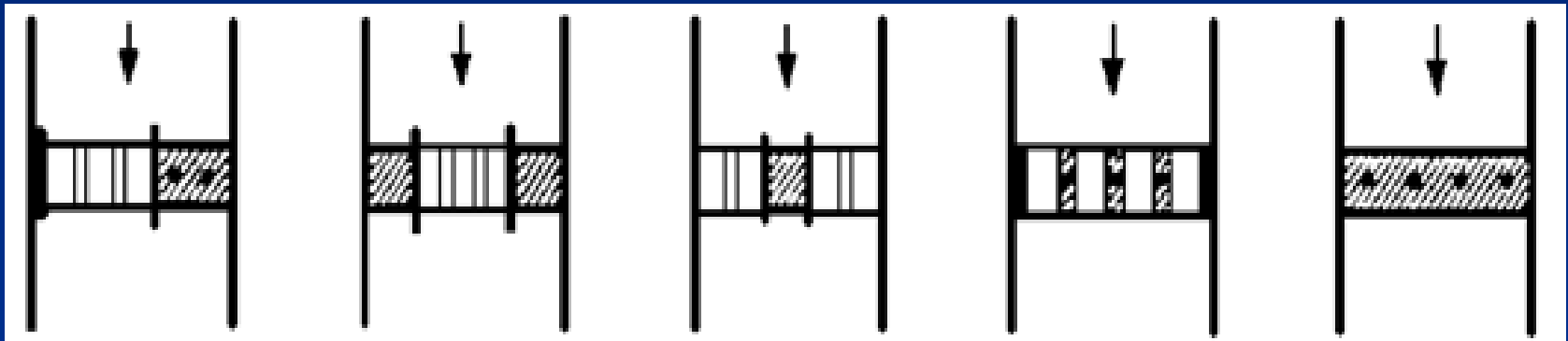
TABLE: HYDROPOWER INSTALLATIONS IN ETHIOPIA

Power Station	Production (MW)	Classification (Mossonyi)
Koka	43.20	High
Soar (SCS)	5.00	Medium
Awash2	32.00	High
Awash 3	32.00	High
Denbi (SCS)	0.80 (0.71)	Low
Fincha	134.00	High
Yadot (SCS)	0.35	Low
Melka Wakena	153.00	High
Tis Abay1	11.40 (12.00)	High
Tis Aby 2	73.00	High
Gilgel Gibe I	184.00	High
Sire (SCS)	0.0055	Midget
Yaye (SCS)	0.17	Low
Total	668.93 (669.44)	

- The most popular & convenient classification is the one based on head on turbine. On this basis:
 - Low head plants $< 15\text{m}$
 - Medium head plants $15\text{-}50\text{m}$
 - High head plants $50\text{-}250\text{m}$
 - Very high head plants $> 250\text{m}$

CLASSIFICATION BASED ON CONSTRUCTIONAL FEATURES (LAYOUTS)

- *Run-off-river plants* (low to medium head plants)
- Valley dam plants (Medium to high head plants)
- Diversion Canal Plants
- High head plants
- Pumped storage plants



a) Block power plant

b) Twin block plant

c) Island plant

d) pier head plant

e) Submersible

plant

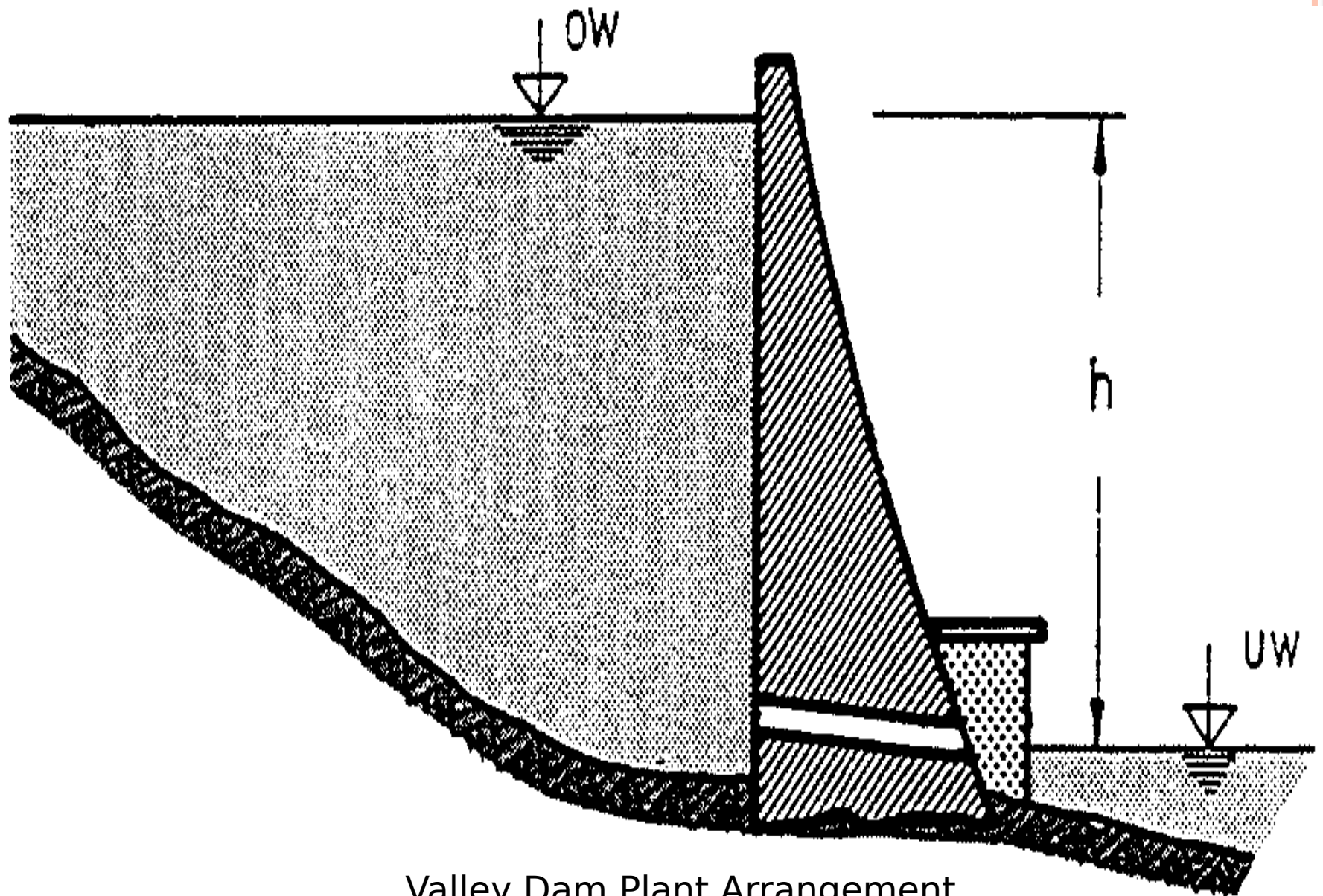
RUN-OFF-RIVER PLANTS (LOW TO MEDIUM HEAD PLANTS)

- The normal flow of the river is not distributed
- There is no significant storage
- A weir or barrage is built across a river & the low head created is used to generate power. It also acts as a control spilling device (Spillway).
- The power house is normally in the main course of the river
- Preferred in perennial rivers with **moderate to high discharge, flat slope, little sediment and stable reach of a river.**
- Water enters the power house through an intake structure incorporating some or all of the following.
 - Entrance flume separated by piers and walls for each machine unit.
 - Turbine chamber: **scroll case with turbine**
 - Concrete or steel draft tube
 - Power house building
- Additional structures:
 - deflector or skimmer walls
 - forebay
 - service bridge
 - river training walls

- The dominant feature is the dam which creates the required storage (to balance seasonal fluctuation) and necessary head for the power house.
- Power house is located at the toe of the dam
- Water flows through the penstock embedded in the dam & enters the power house.
- Sometimes the power house is not immediately at the toe of the dam but at some distance (eg. the Koka power plant). This arrangement is more expensive (due to longer conveyance) and is used only when it offers advantages such as extra head due to advantageous topographical conditions.

Important components of a valley dam plant

- the dam with its appurtenance structures like spillway, energy dissipation arrangements etc.
- the intake with racks, stop logs, gates & ancillaries
- the penstock conveying water to the turbine with inlet valve & anchorage.
- the main power house with its components.

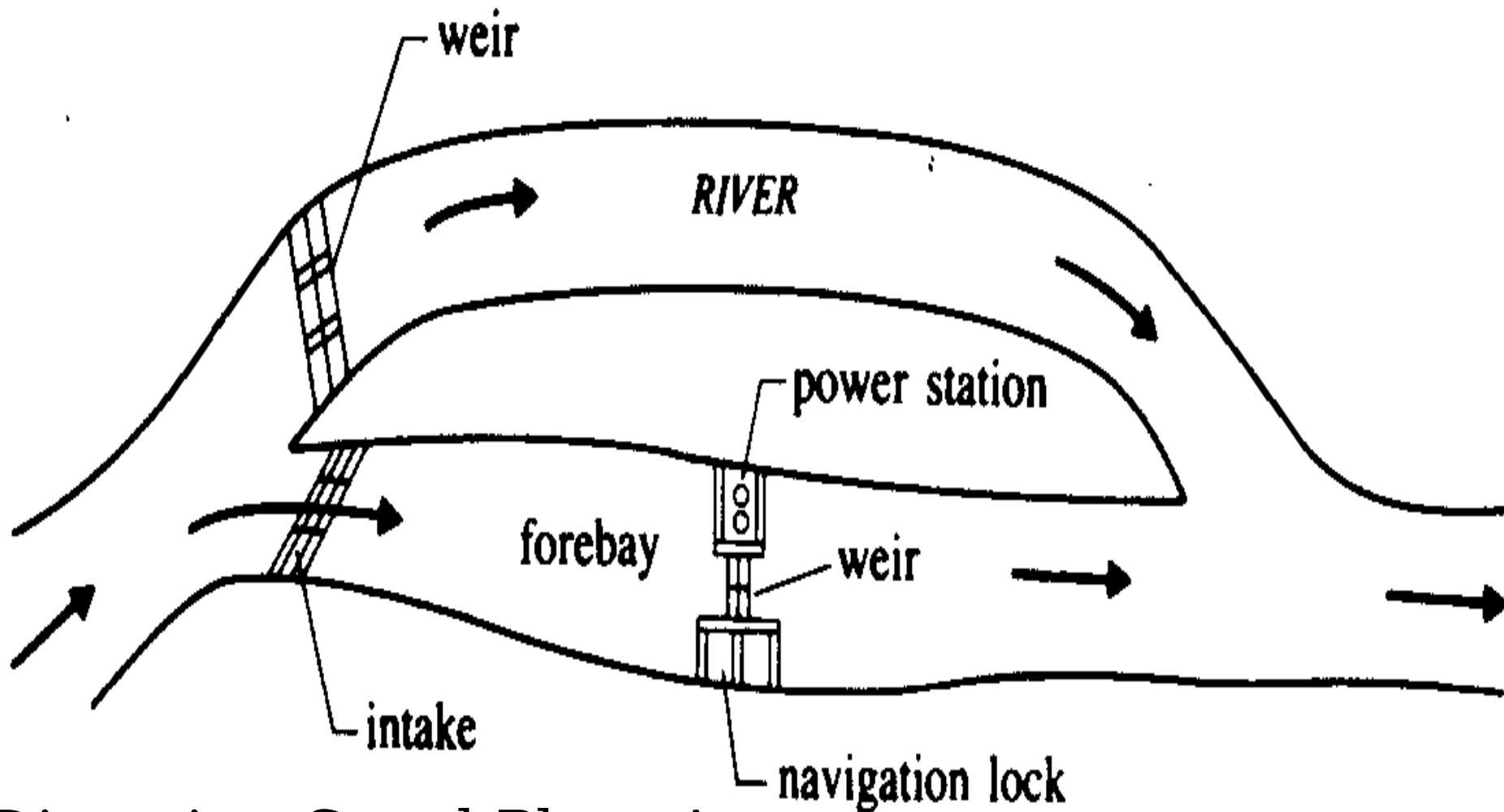


Valley Dam Plant Arrangement

❖ ***Diversion canal plant***

- The distinguishing feature is the **presence of power canal that diverts the water from the main stream channel.**
- The power house is provided at suitable location along the stretch of the canal
- The water often flowing through the turbine is brought back to the old stream very shortly.
- Diversion canal plants are generally **low head or medium head plants.**
- They don't have storage.
- Pondage requirement is met through a pool called forebay located just u/s of the power house.
- Ways of developing required head
 - The flatter slopes of power canal and the absence of meander, by reducing length, helps in providing head.
 - If the river has a natural fall, diverting the water from u/s side of the fall & locating the power house at the d/s side of the fall provide the required head (e.g. Tis Abay-II HP).
 - In inter-basin diversion, water may be diverted from a higher level river to a lower river through a diversion canal to the power house located at the lower river.

- Main structures of the diversion canal plant:
 - Diversion weir with its appurtenant structures.
 - Diversion canal intake
 - Bridges and culverts of the canal.
 - Forebay & its appurtenant structures.

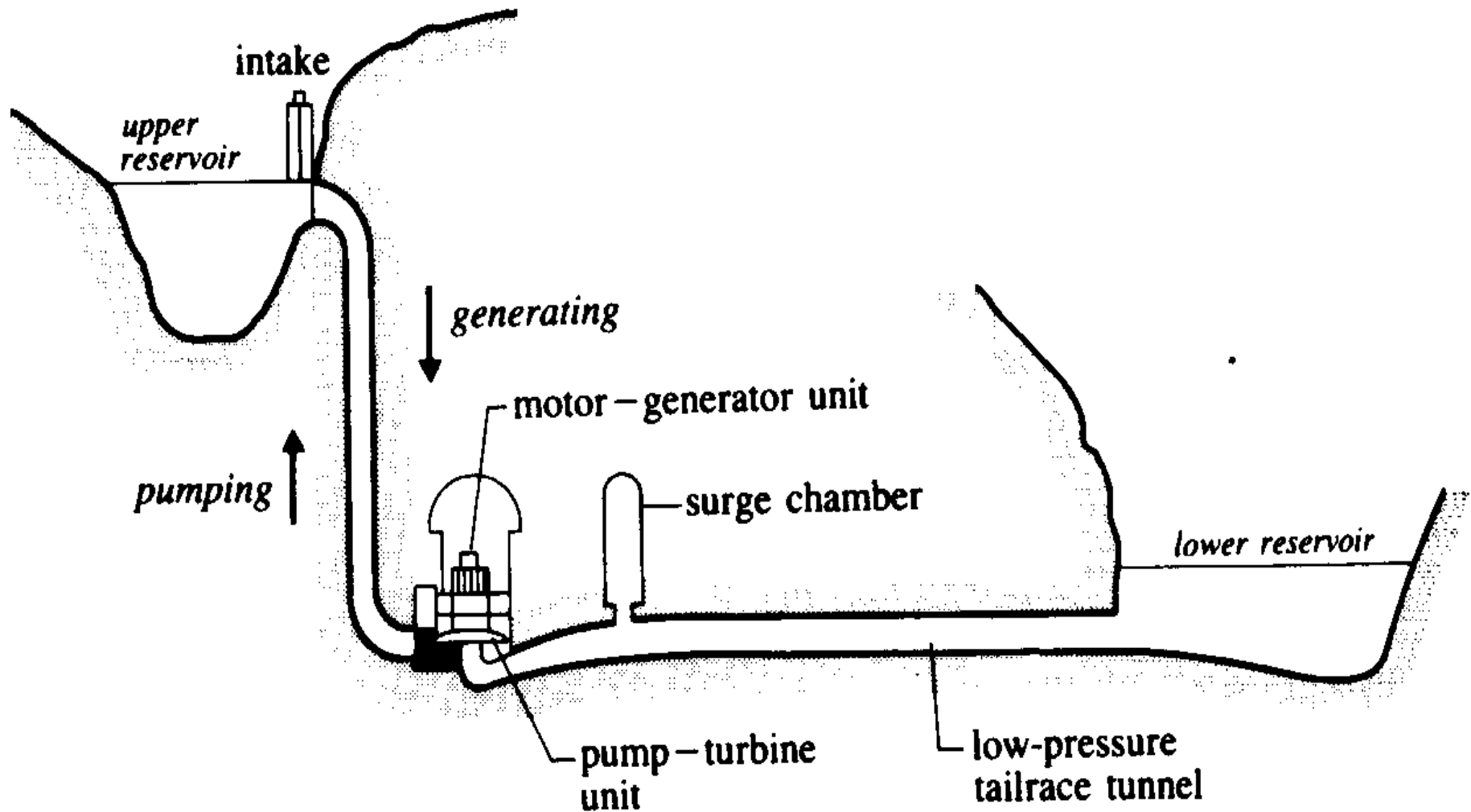


Diversion Canal Plant Arrangement

HIGH HEAD DIVERSION PLANTS

- High head is developed by:
 - diverting the river water through a systems of canals and tunnels to a downstream point of the same river.
 - Diverting the water through canals and tunnels to a point on another river which is at much lower level.
- There may be two options concerning storage situation
 - A diversion weir to create pondage (and no storage). Here like run-off-plant the **power production is governed by the natural flow in the river.**
 - Storage may be provided on the main river at the point of diversion. (This second option is advantageous since the fluctuation in reservoir level does not materially affect the head and the power output can be adjusted by the controlled flow release from the reservoir. Eg. Fincha & Melka Wakana power plants)
- Main Components of high head diversion plants:
 - Storage or diversion weir with appurtenant structures
 - The canal/tunnel
 - The head race either open cut or tunnel.
 - Forebay/surge tank
 - Penstock
 - Power house
 - The tail race

- ❖ Pumped storage plant is suitable where:
 - the natural annual run-off is insufficient to justify a conventional hydroelectric installation
 - it is possible to have reservoir at head & tail water locations.
 - This kind of plant generates energy for **peak load, & at off peak period water is pumped back for future use.** During off peak periods excess power available from some other plants in the system is used in pumping back water from the lower reservoir
- ❑ Various arrangements are possible for higher and lower reservoirs:
 - Both reservoirs in a single river
 - Two reservoirs on two separate rivers close to each other and flowing at different elevations
 - Higher reservoir an artificially constructed pool and the lower reservoir on natural river
 - The lower reservoir in a natural lake while the higher is artificial
 - Another way of classifying is as pure pumped storage



Pumped Storage Plant arrangement

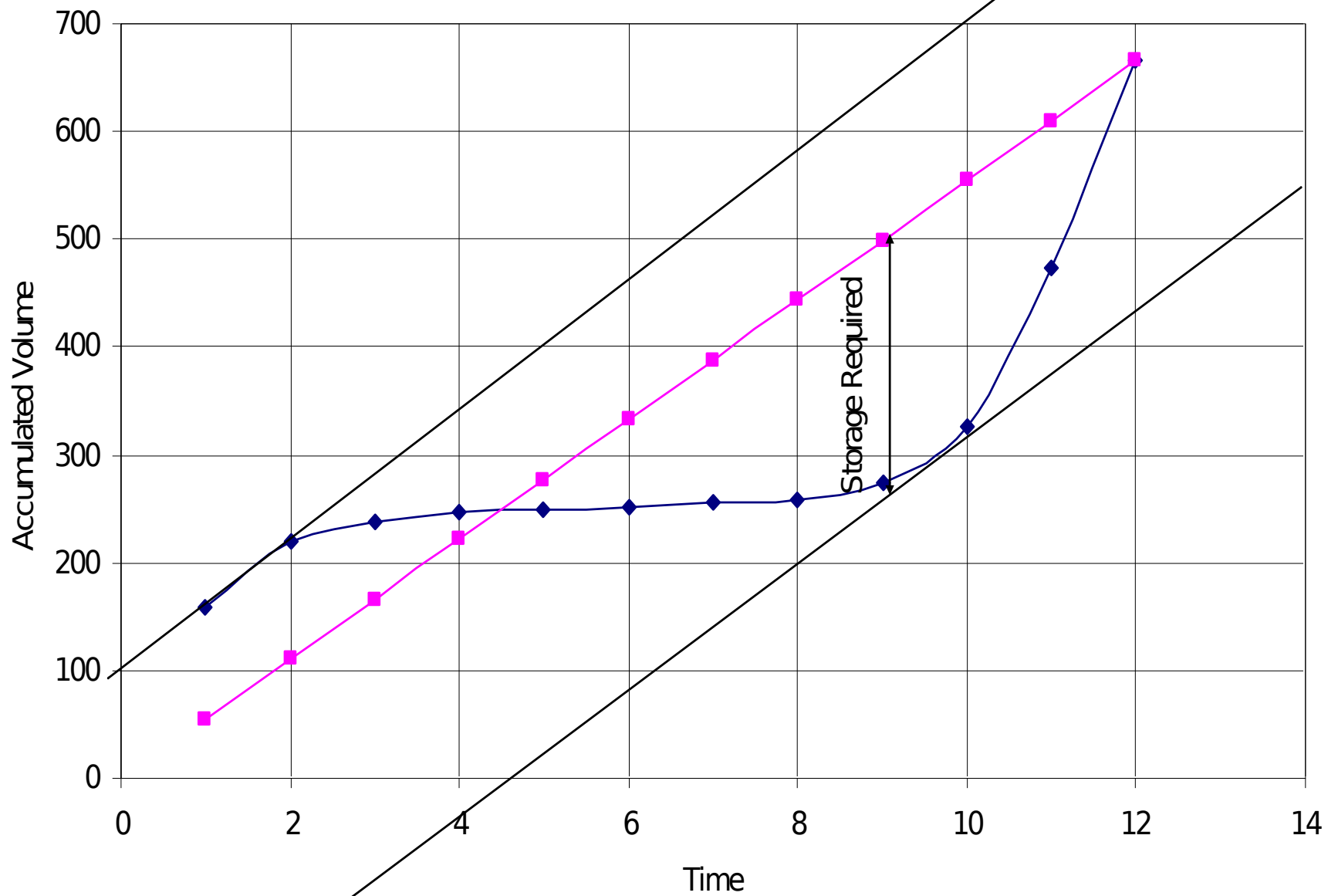
Storage and Pondage

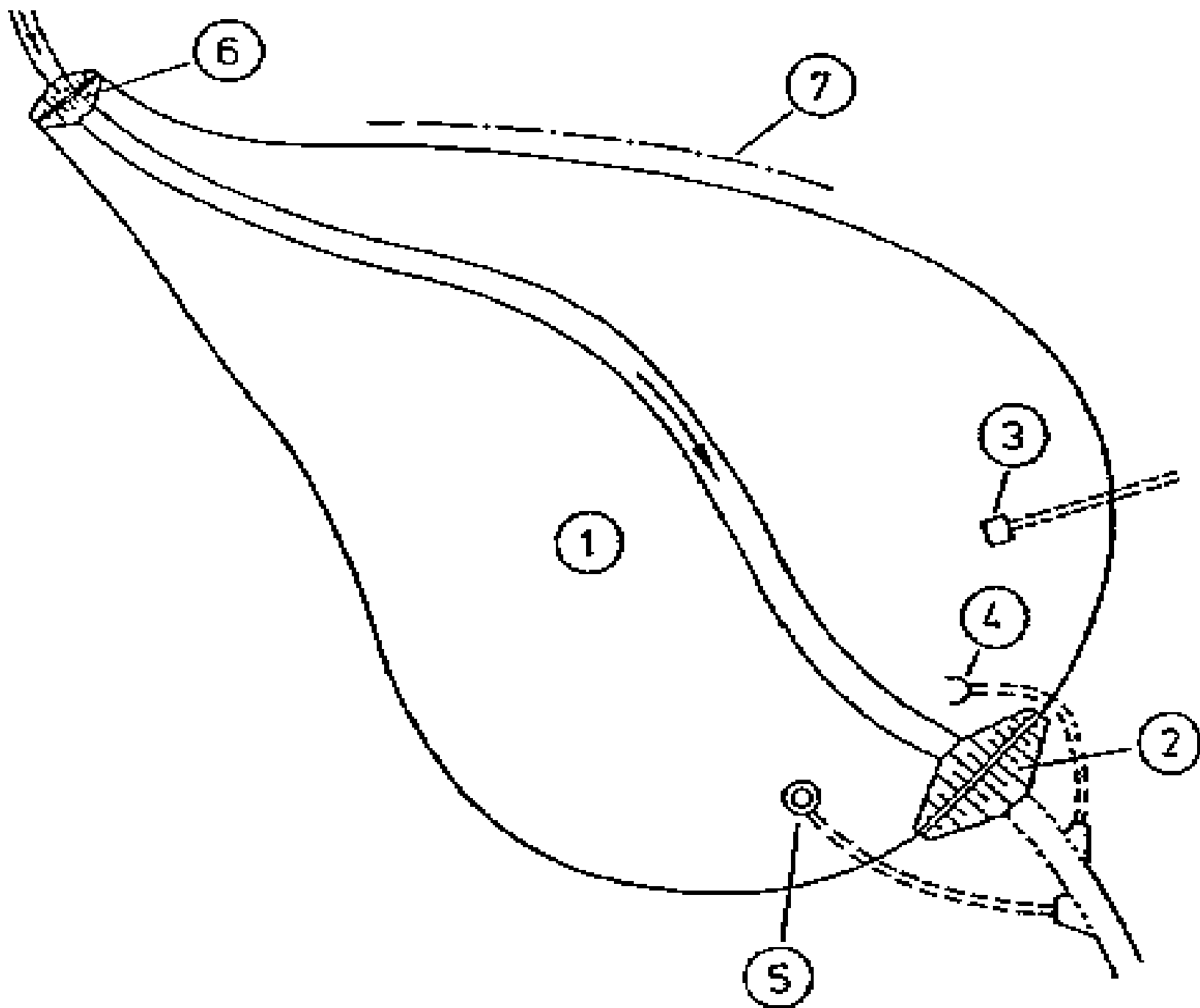
- Storage is provide to balance seasonal fluctuation by building reservoir dams.
- Pondage is provided through balancing reservoir or forebay for short term fluctuations (daily or hourly)

Reservoir (storage) capacity

- Reservoir capacity is determined by means of mass curve procedure of computing the necessary capacity corresponding to a given inflow and demand pattern. Reservoir capacity has to be adjusted to account for the dead storage, evaporation losses and carry over storage

Mass Curve





- Storage -----(1)
- Dam----- (2)
- Appurtenant Structure: Intake and Spillage Structures:
 - Spillage Structure: Spillway----- (5)
 - Intake:
 - Service Intake -----(3)
 - Bottom Outlet----- (4)
 - Surveillance Structure (in Dam, in Foundation as well as Valley Sides)
 - Diversion----- (6)
 - Service Road -----(7)

