SAARC ENERGY CENTRE
Energy for Peace & Prosperity

Online training of SAARC Professionals on Small, Mini and Micro Hydro Power Generation (Sept 13 - 17, 2021)

Site Selection and Investigation of SMMHP Plants

Sept 13, 2021

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CONTENTS

- Small Hydropower
- Criteria for site selections of various type of SHP schemes
- Surveys and Investigations stages and type of investigations required for development of SHP scheme

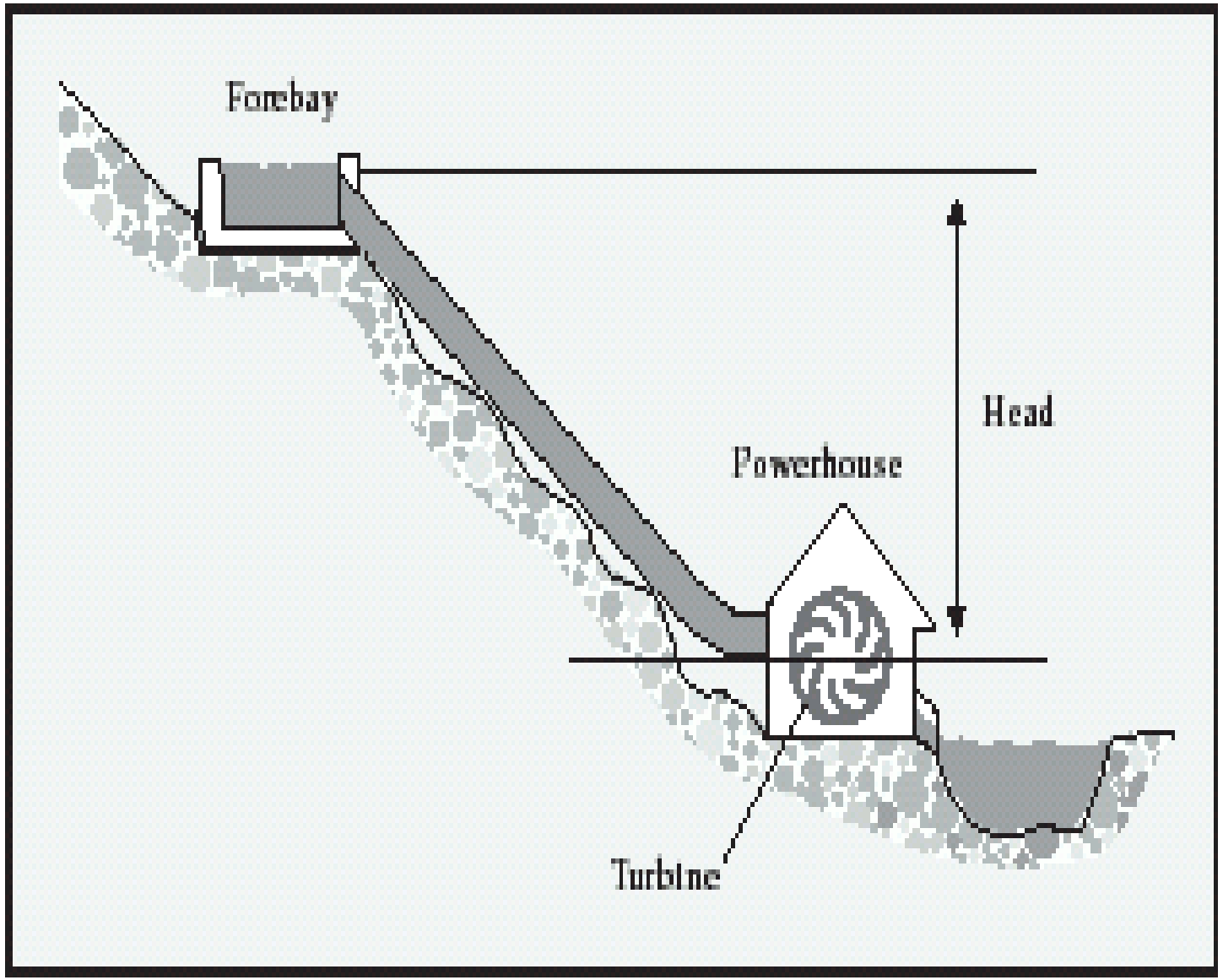
LEARNING OBJECTIVES

basis of selection of sites for shp development and surveys and investigations

WHAT IS SMALL HYDROPOWER

- Water is fed from stream/canal to the turbine by a closed pipe (penstock) through diversion works. The turbine in turn rotates the generator for electricity generation.

Power (kW) = 9.81 × Discharge (cum/s) × Head (m) × Efficiency


Forebay
Head
Powerhouse
Turbine

EFFICIENCY OF HP STATION AND EQUIPMENT

- **Efficiency of hydropower**

  = efficiency of turbine* generator* gearbox

- **Turbine** **88 to 94%**
- **Generator** **96 to 98%**
- **Gearbox** **98%**
- **Weighted average efficiency** **75%**

TYPE OF SCHEMES

- **RUN OF RIVER**

  No storage.

  The output is subject to instantaneous flow.

  Reliability of discharge and geological conditions should be ensured.

- **CANAL BASED**

  Utilizes the fall and flow in the canals.

  May be planned in main canal or in bye-pass canal.

  Nearby drops should be clubbed in existing canals.

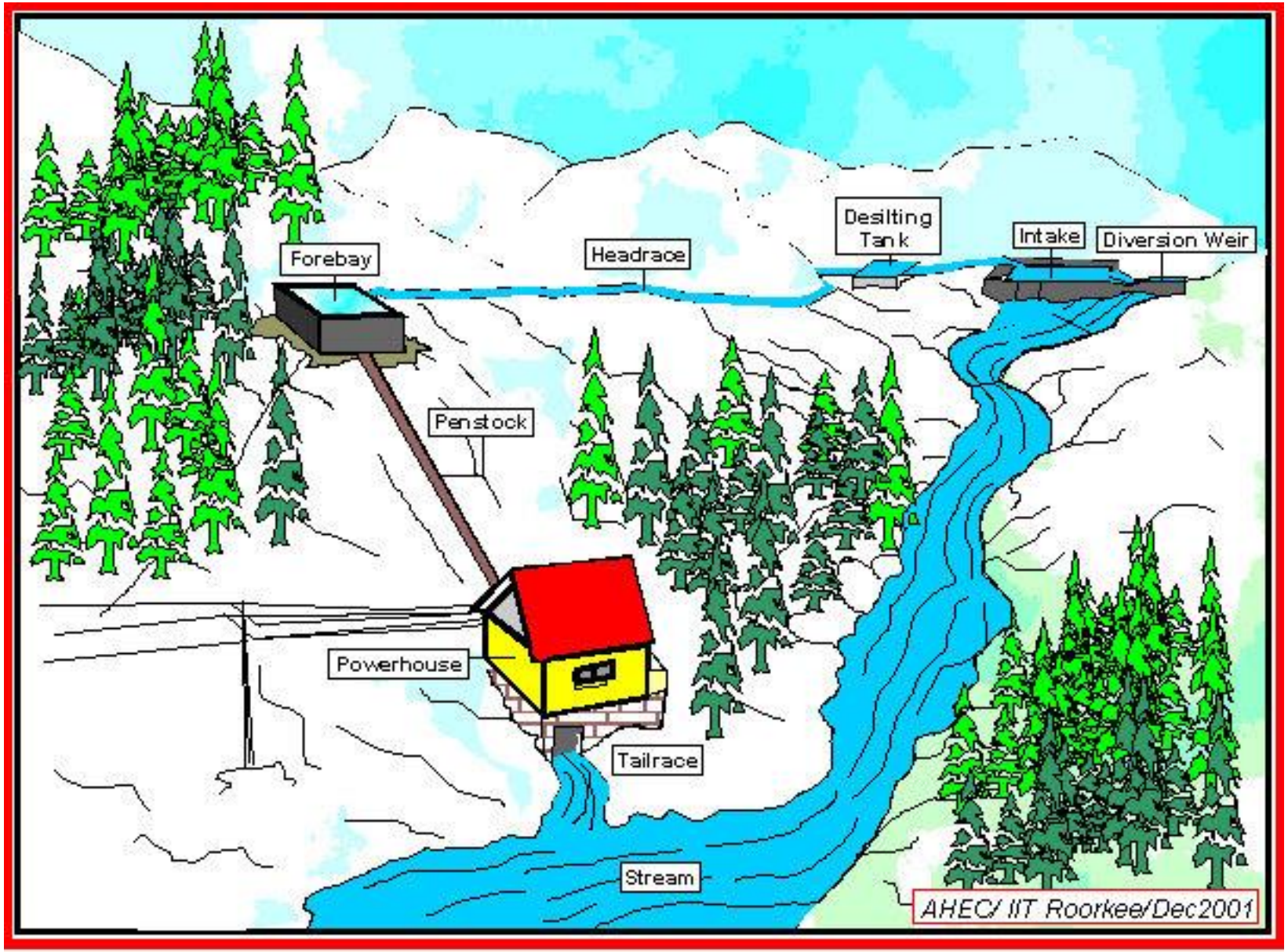
  In canals under planning concentrated drops should be considered.

- **DAM BASED**

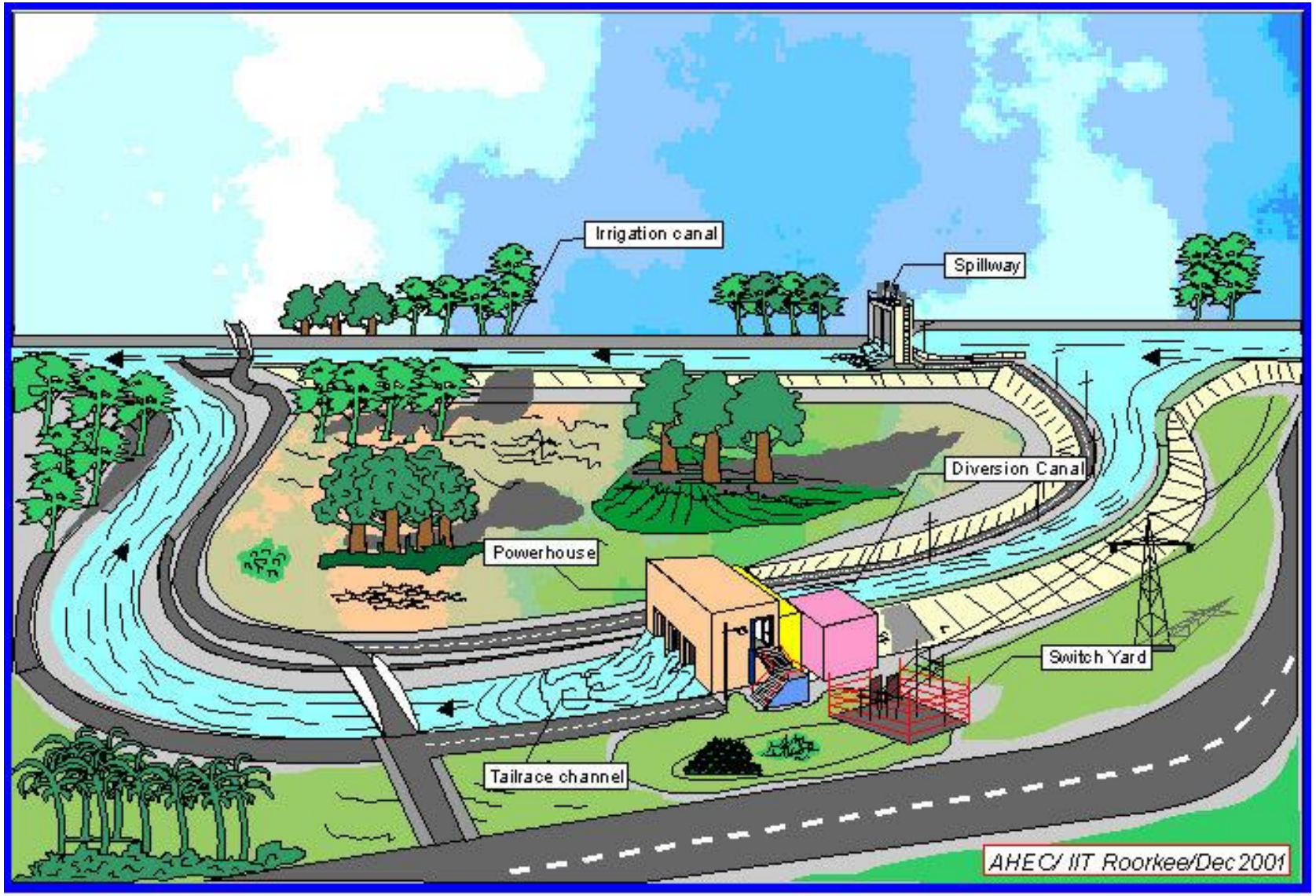
  Dam toe schemes are most common in India.

  Water stored during monsoon is utilized for power generation.

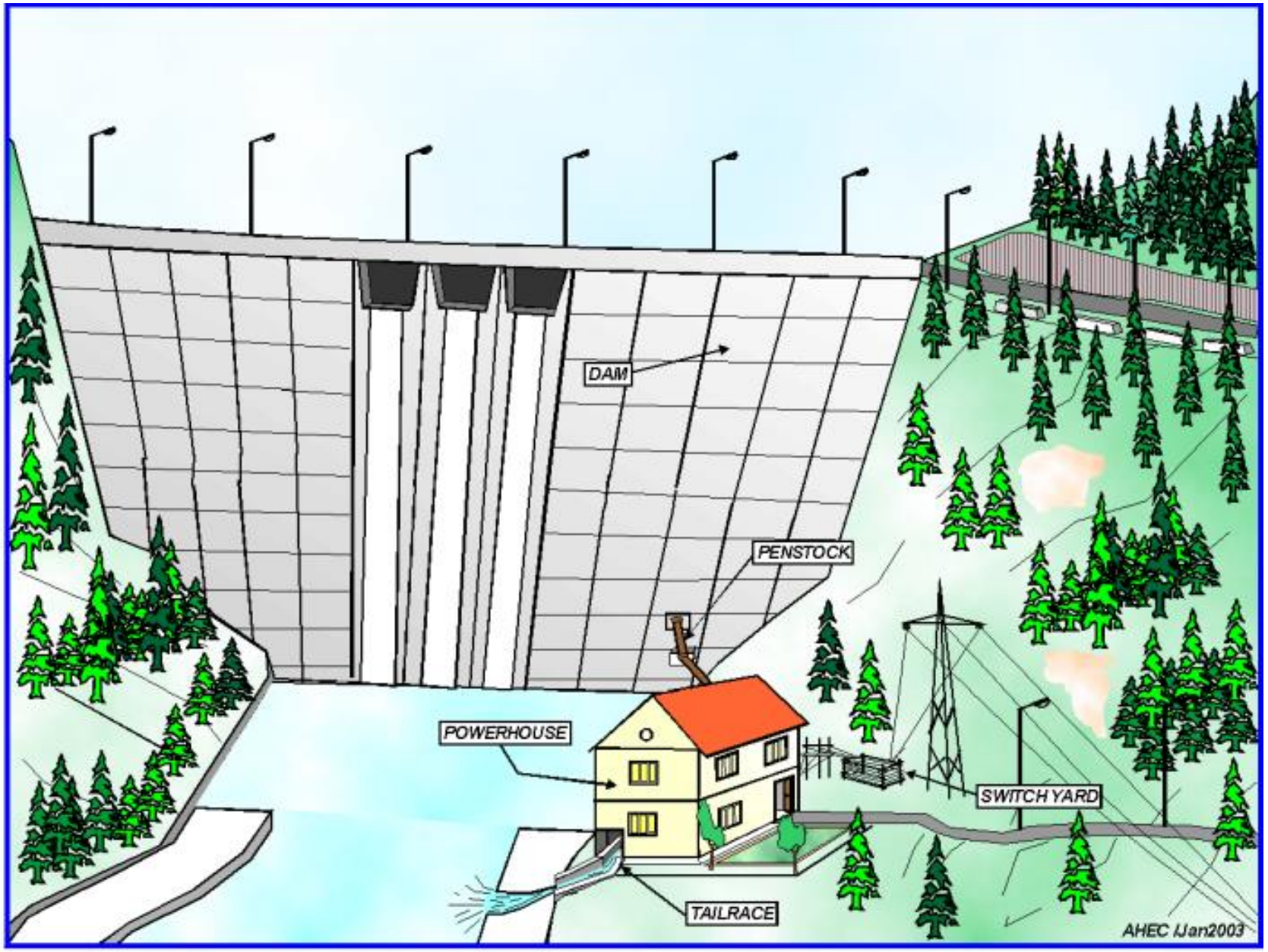
- **PUMP STORAGE**



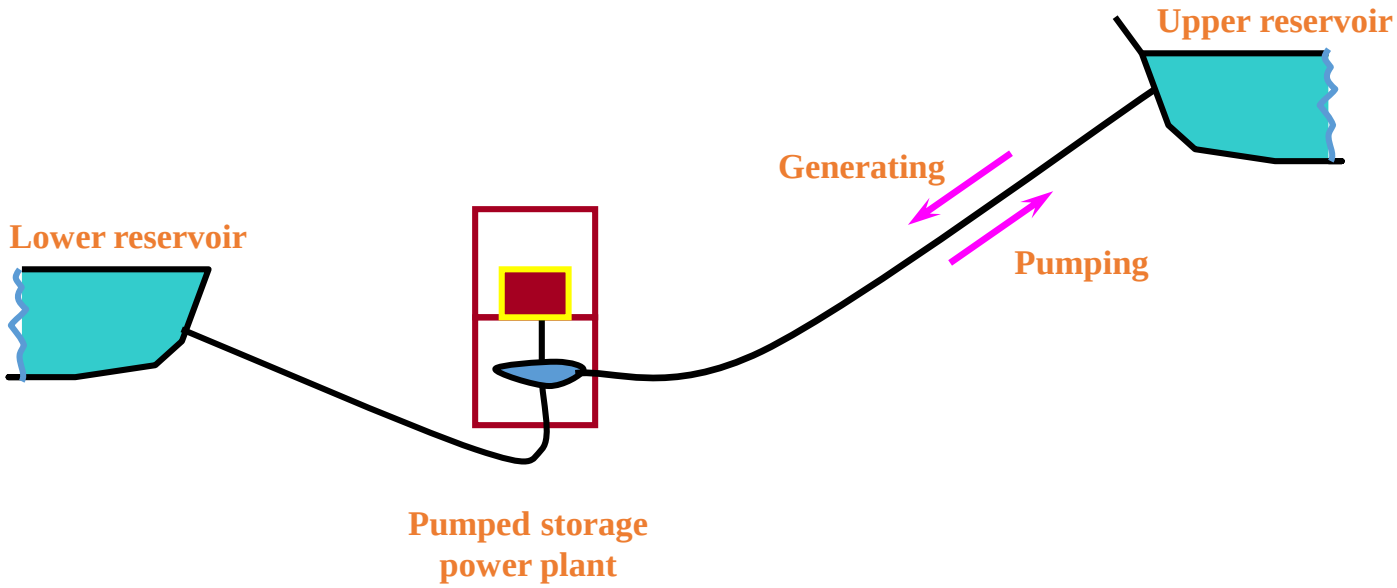
Typical Arrangement of Small Hydro Power Station



Typical Arrangement of Canal Fall Small Hydro Power Station



Typical Arrangement of Dam toe Small Hydro Power Station



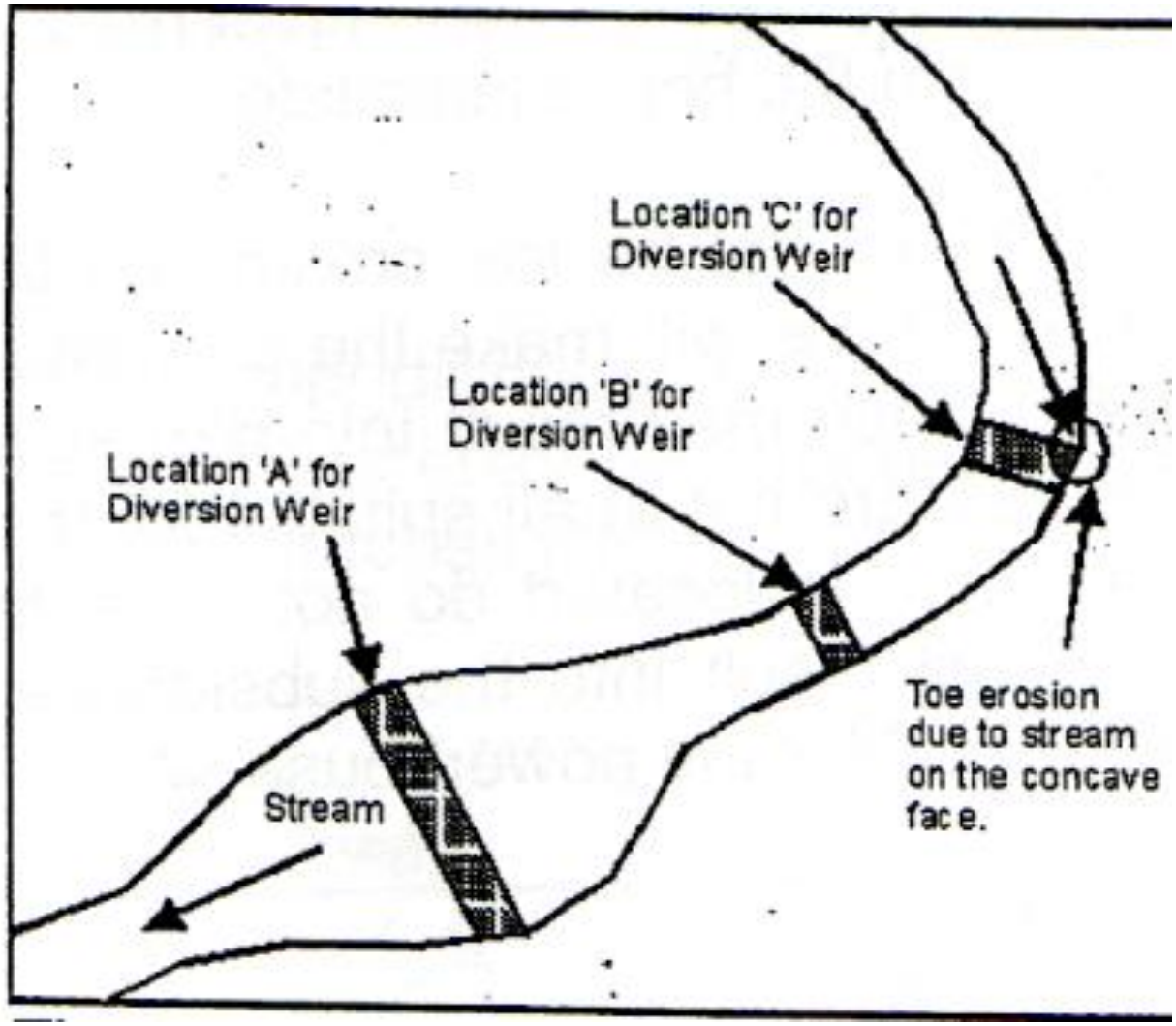
Pumped Storage Scheme Configuration

SITE SELECTION – ROR SCHEMES

INTAKE

- Should be at narrow valley.
- Bends should be avoided.
- Banks should be stable.
- No land slides.
- Minimum turbulence in flow.

DIVERSION WEIR AND INTAKE SITE



DESILTING TANK AND CHANNEL

- Flatter land.
- Free from cross drainages.
- No active slide zone.
- Slopes should be stable.

FOREBAY AND SPILLWAY

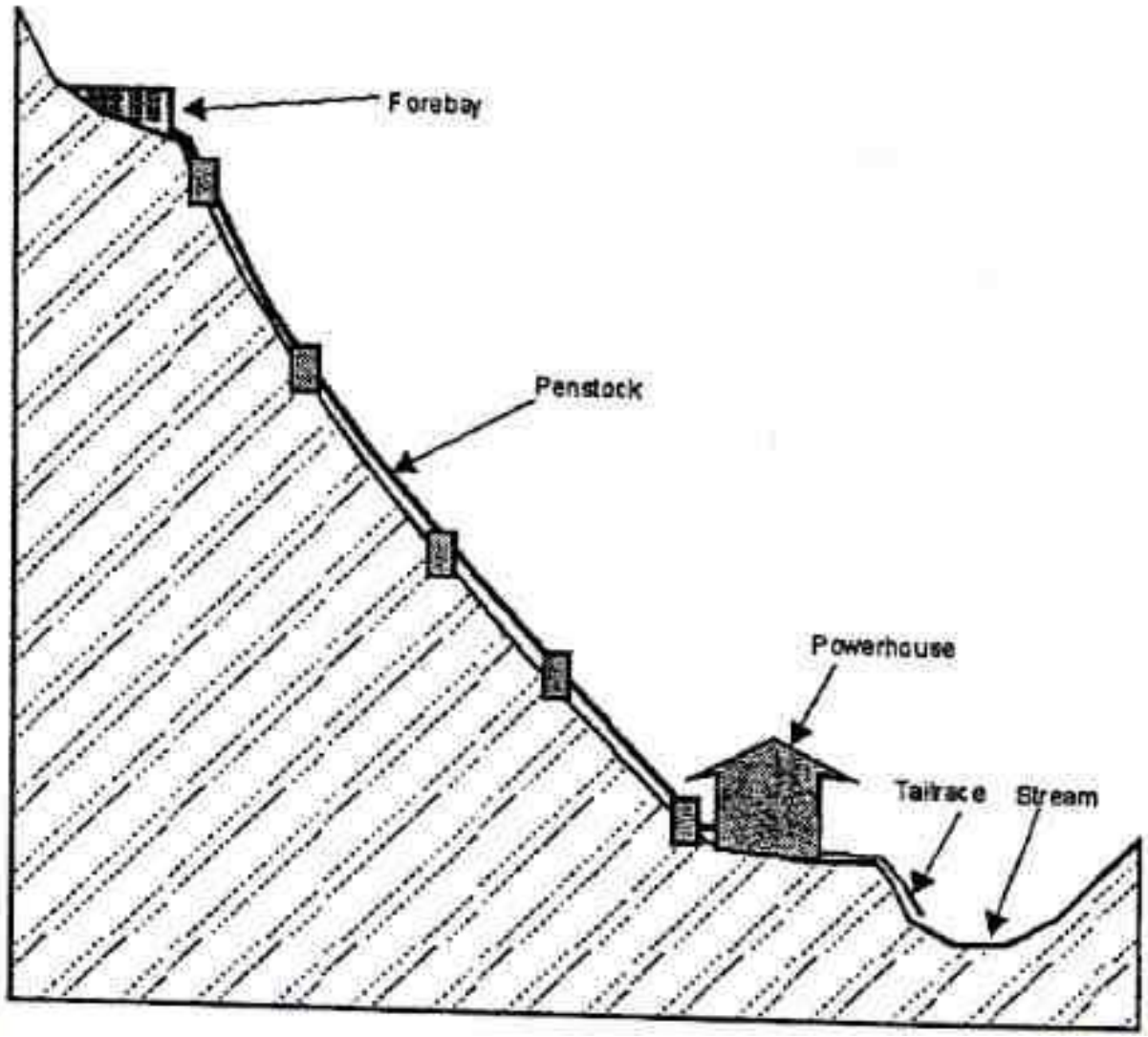
- Flatter land.
- Filling of land should be avoided.
- Slopes should be stable.
- Natural stream should be nearby for spill water.

PENSTOCK

- Alignment should be along the ridge.
- Shortest length.
- Minimum bends.

POWER HOUSE

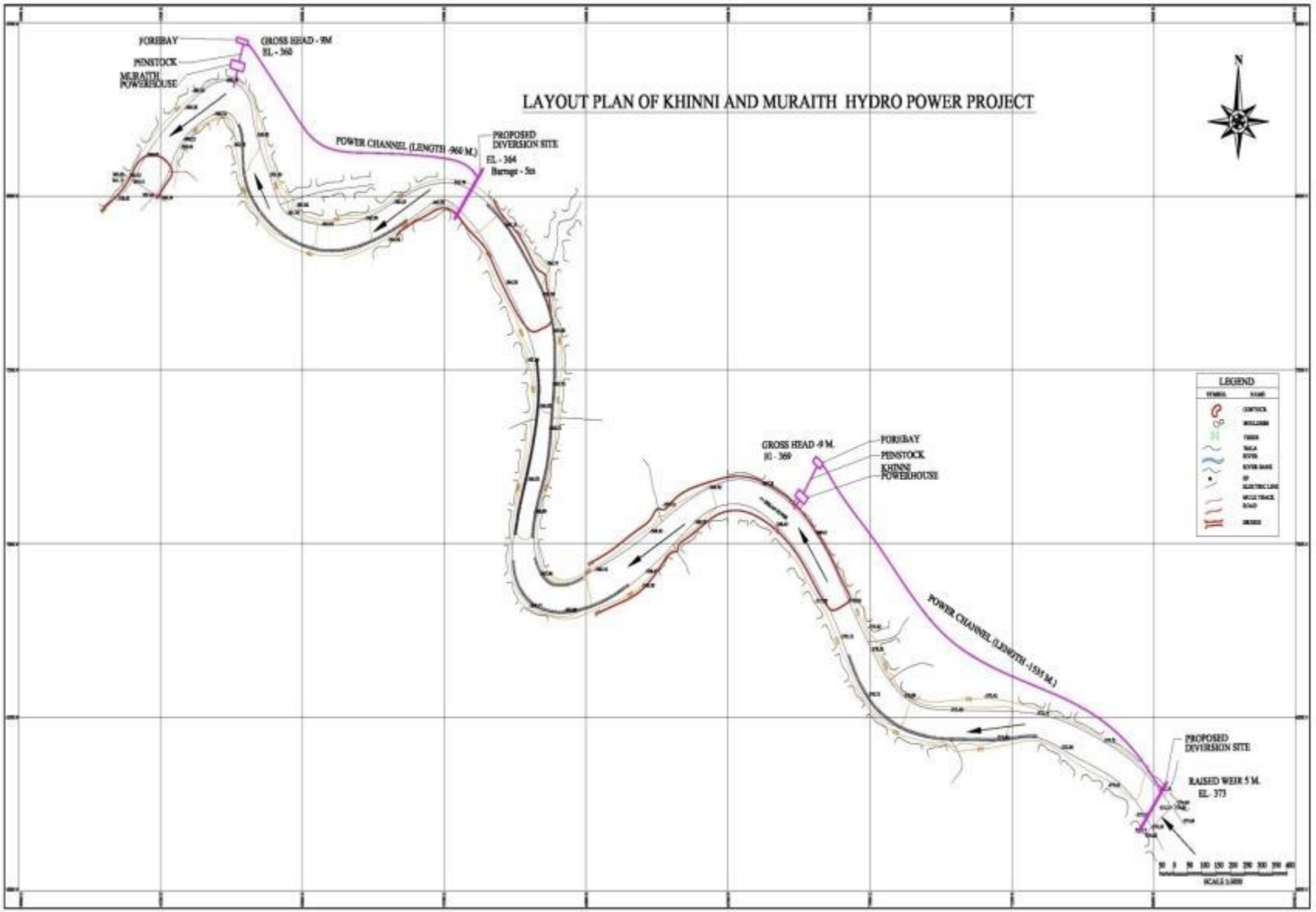
- Easy accessibility.
- Flatter ground.
- Above high flood level.
- Stable slope.


Forebay
Penstock
Powerhouse
Tailrace
Stream

RUN-OF-RIVER: River with rapids and drops

RUN-OF-RIVER: River with mild slope

LAYOUT PLAN OF RUN-OF-RIVER SITE



CANAL BASED SHP SCHEME

- Power house may be located in diversion channel on either bank
- Power house may be located in the canal itself.
- Location of spillway
- Proximity of substation for power evacuation
- Accessibility
- Land availability

DAM BASED SHP SCHEME

- For dam based, same as ROR scheme
- For dam toe, Proximity of substation, land availability and
- Accessibility

PUMP STORAGE BASED SHP SCHEME

- Suitable site for upper and lower reservoir
- Suitable site for location of power house
- Alignment of penstock

OTHER POSSIBLE LOCATIONS FOR SHP

- Cooling water return channel
- Velocity head or kinetic energy
- Very low head

Surveys and INVESTIGATIONS FOR SHP

INVESTIGATIONS

Investigation Stages

1. Reconnaissance level (preliminary/PFR)
2. Feasibility/Detailed level (pre-investment/DPR)
3. Execution

RECONNAISSANCE LEVEL

At this level of investigations following should be determined

- Hydrological survey
- Topographical survey
- Geological survey
- Power load demand assessment
- Socio- economic survey
- Head and discharge.
- Technical feasibility of the project.
- Identification of critical issues and their possible solutions.

DETERMINATION OF HEAD

- By altimeter
- By GPS
- By Dumpy level
- By total station
- Water filled tube

DETERMINATION OF HEAD

- By altimeter – very approximate
- By GPS – approximate
- By Engineering level – reasonable
- Theodolite and Total Station – accurate
- Map – very rough
- Water filled tube – crude but accurate

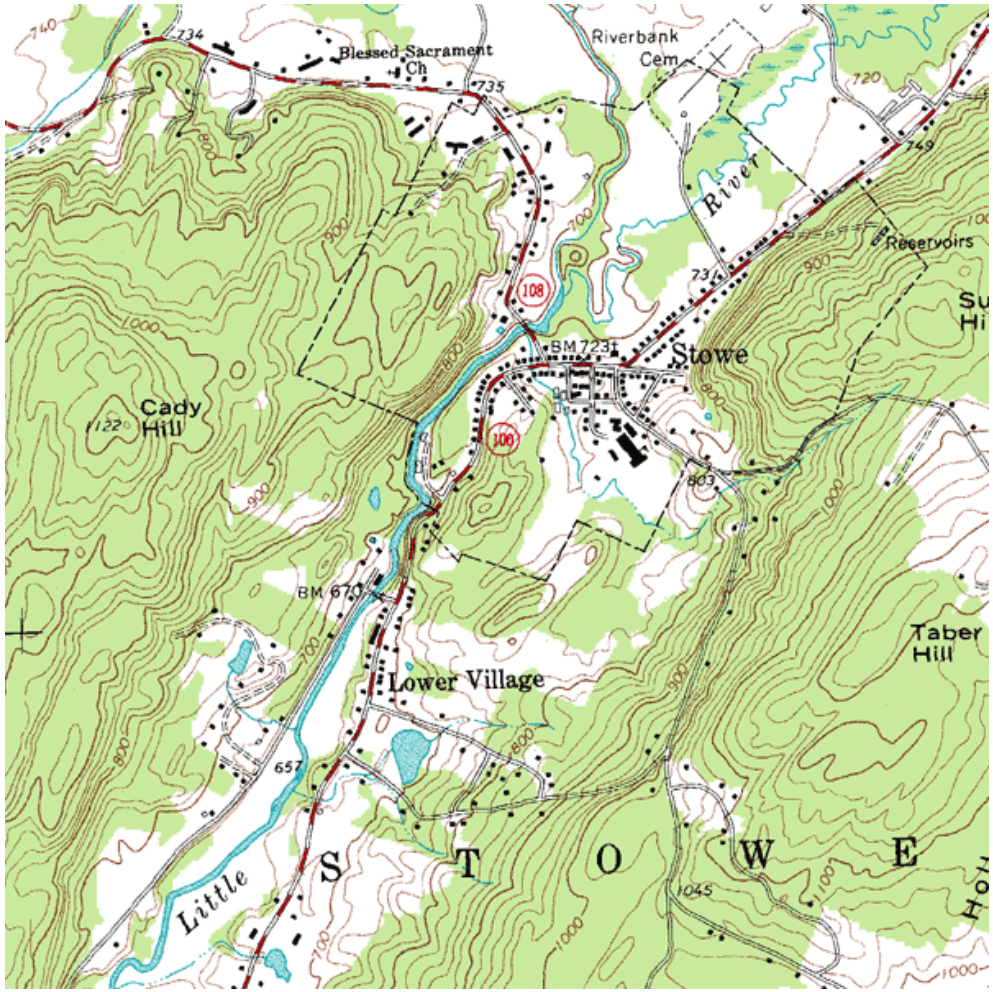
GLOBAL POSITION SYSTEM

- **HANDHELD**
- **MOUNTED**

METHODOLOGIES FOR HEAD ESTIMATION

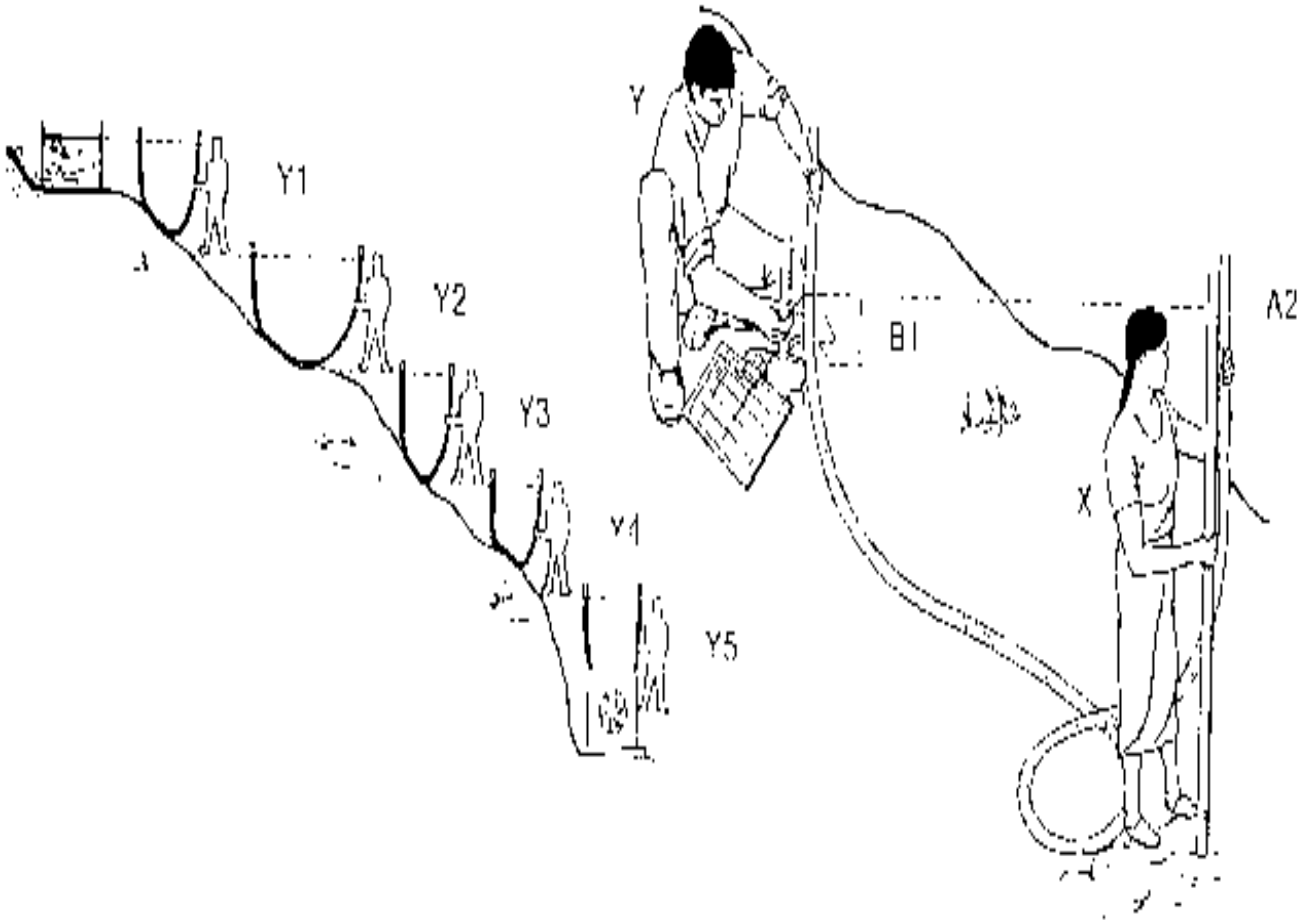
1. USING DETAILED MAPS

Detailed topographic maps are useful for locating potential sites and for obtaining a rough estimate of head levels.



2. Water-filled Tube and ROD Method

This method is suitable for low-head sites. It is reliable, reasonably accurate and inexpensive.



ENGINEER'S LEVEL

- A telescope mounted so that it can be levelled to make the axis horizontal only

HYDROLOGICAL SURVEY

- Collection of discharge data as available
- Measurement of discharge once or twice
- Assessment of discharge for whole year

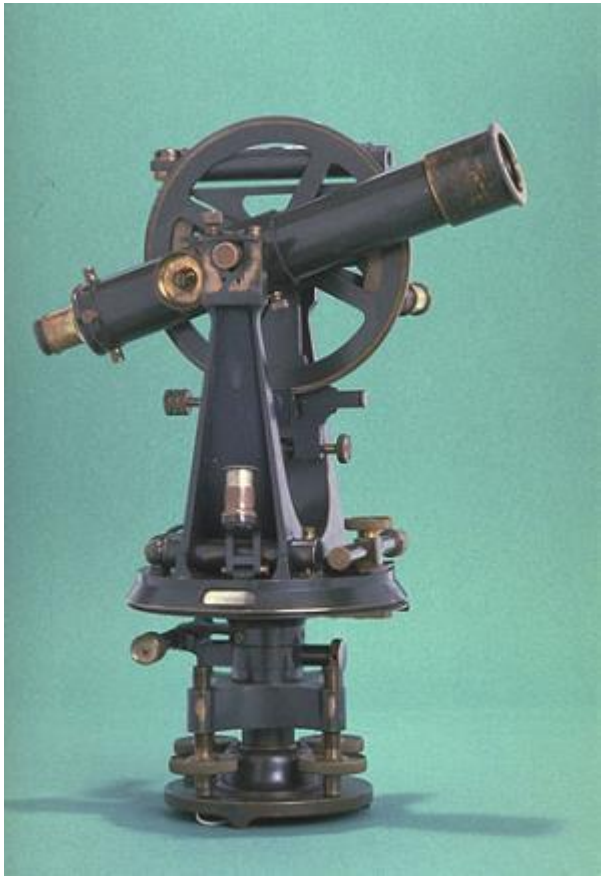
FEASIBILITY/DETAILED PROJECT REPORT-INVESTIGATIONS

- Hydrological survey
- Topographical survey
- Geological survey
- Power load demand assessment
- Socio- economic survey
- Meteorological survey
- Environmental survey
- Survey for construction material
- Power Evacuation Line Survey
- Muck Disposal area Survey

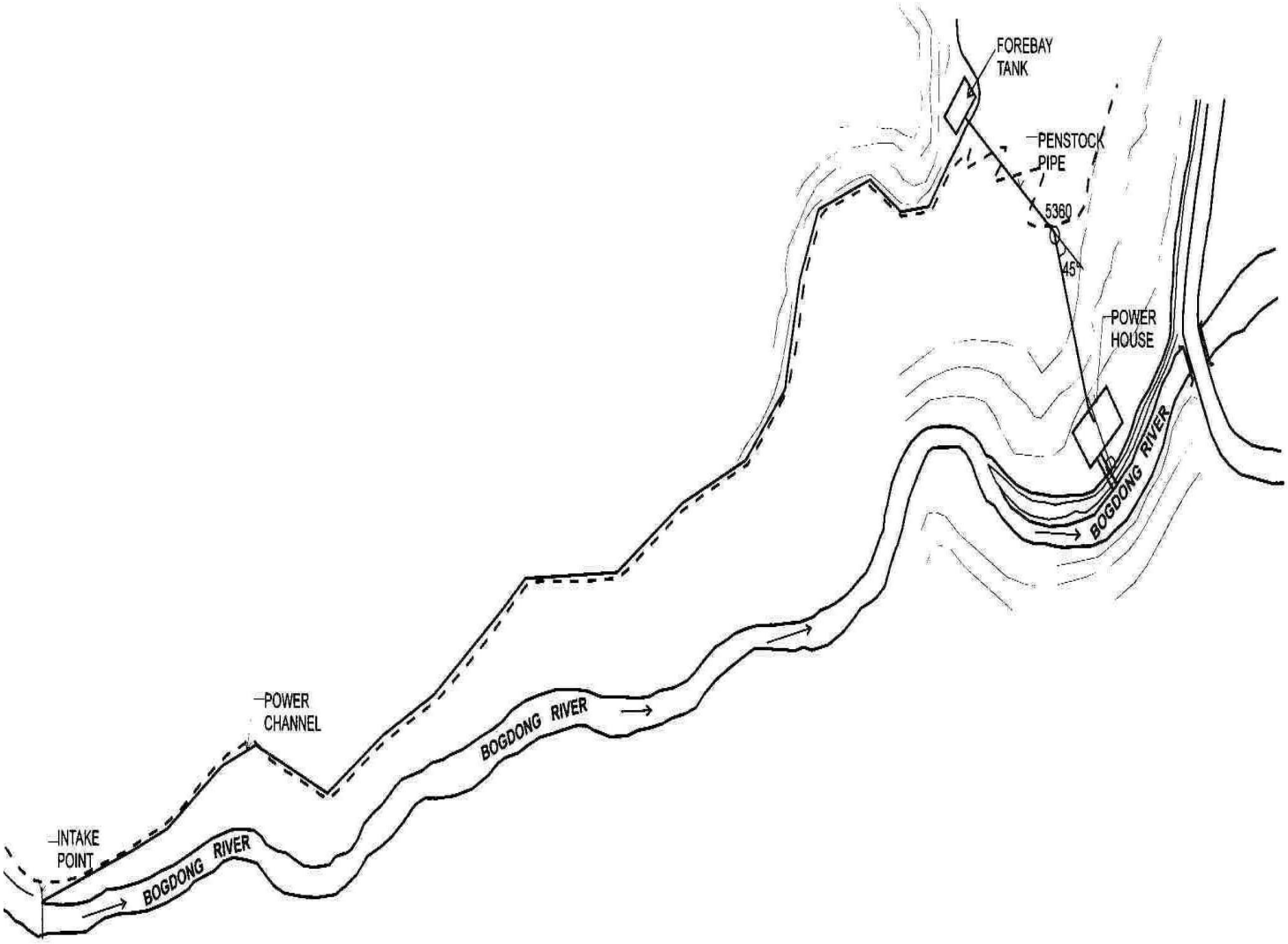
TOPOGRAPHICAL SURVEYS

- Distances
- Angles
- Directions
- Elevations
- Coordinates

VERNIER THEODOLITE

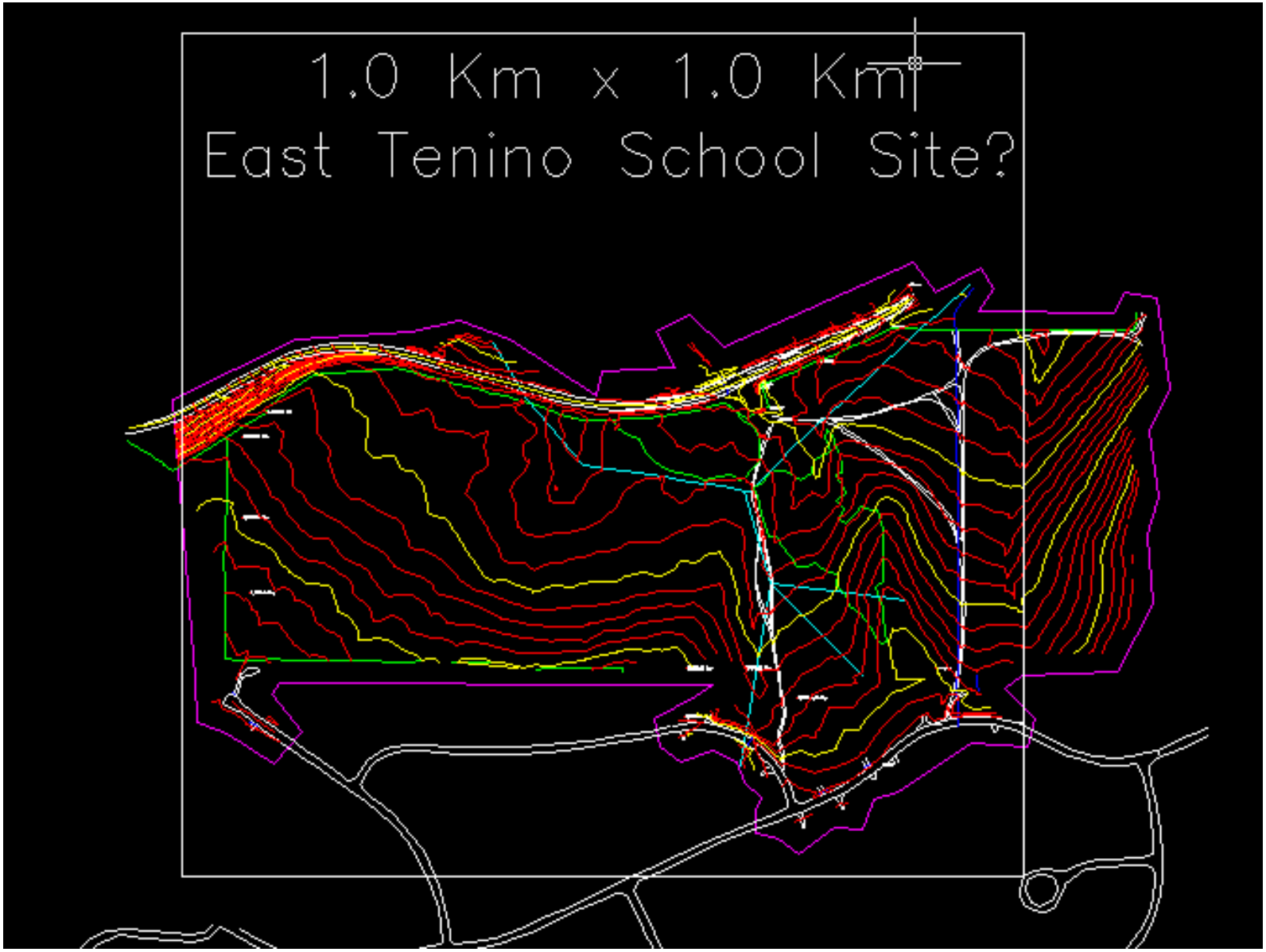


TOPOGRAPHICAL SURVEY

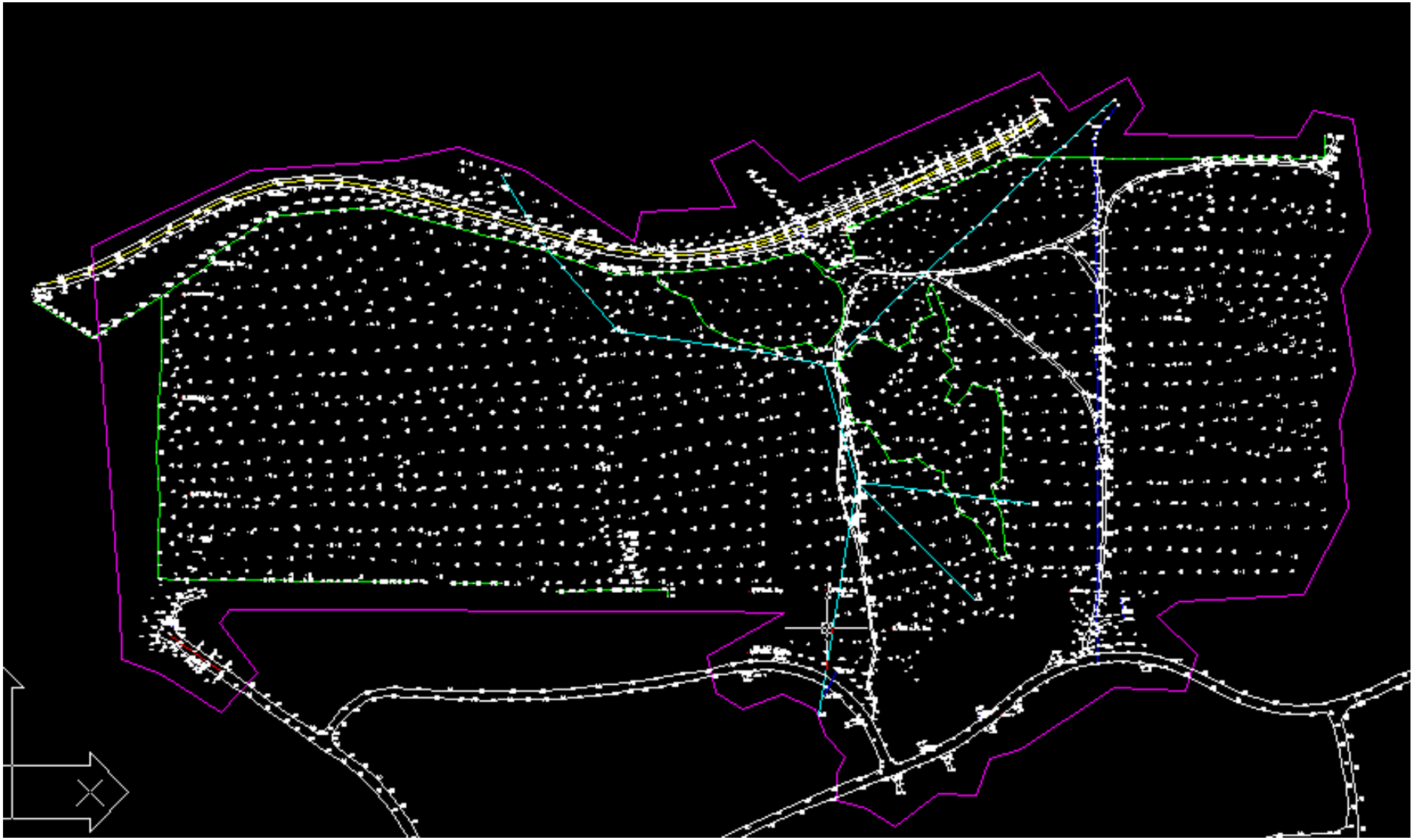


TOTAL STATION
Main Body

CONTOUR MAP OF PROJECT SITE



TOTAL POINTS COLLECTED



FLOW MEASUREMENT

Indirect methods

- Velocity-area method
- Weir method

Direct methods

- Salt dilution method

RECTANGULAR NOTCH

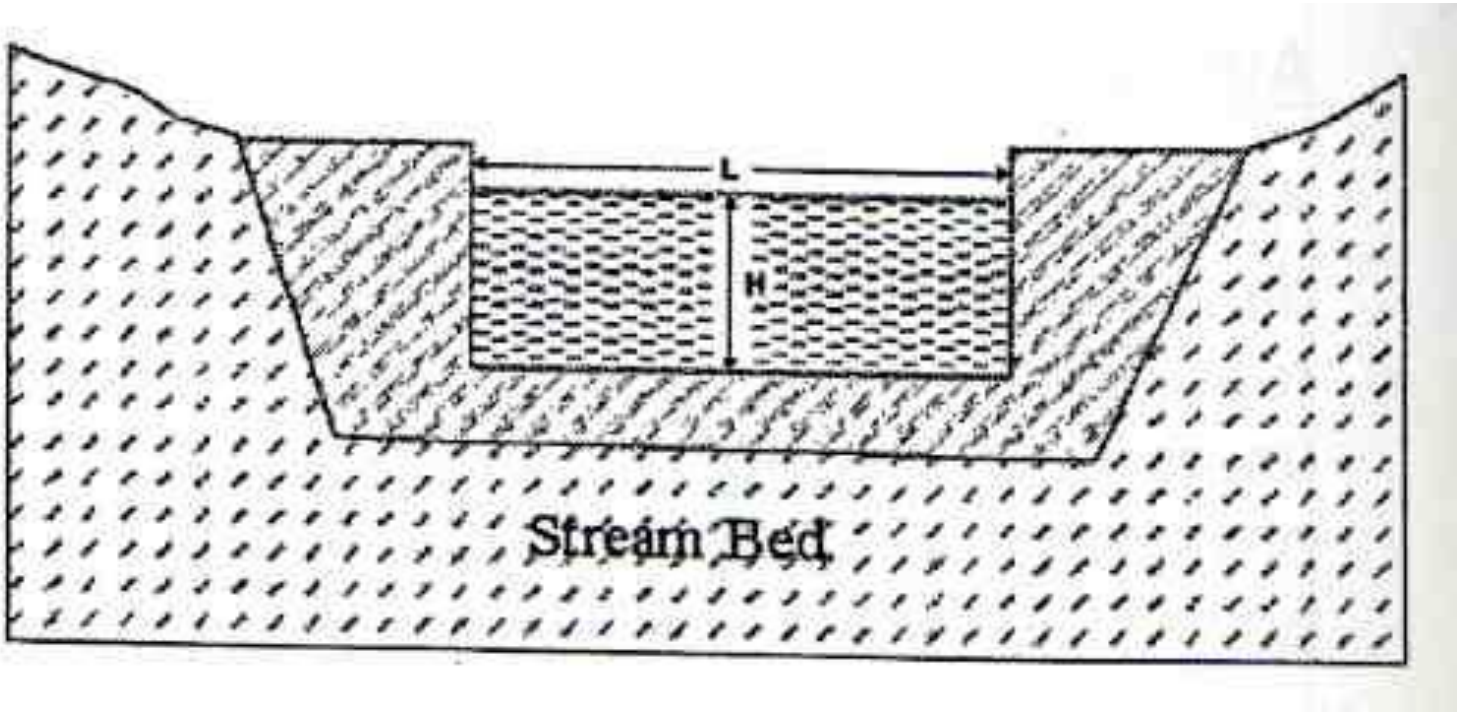
$Q = 1.8 (L-0.2H) H^{3/2}$

Where,

'Q' is discharge in cumecs

'L' is the length of the rectangular notch.

'H' is the height of water in notch



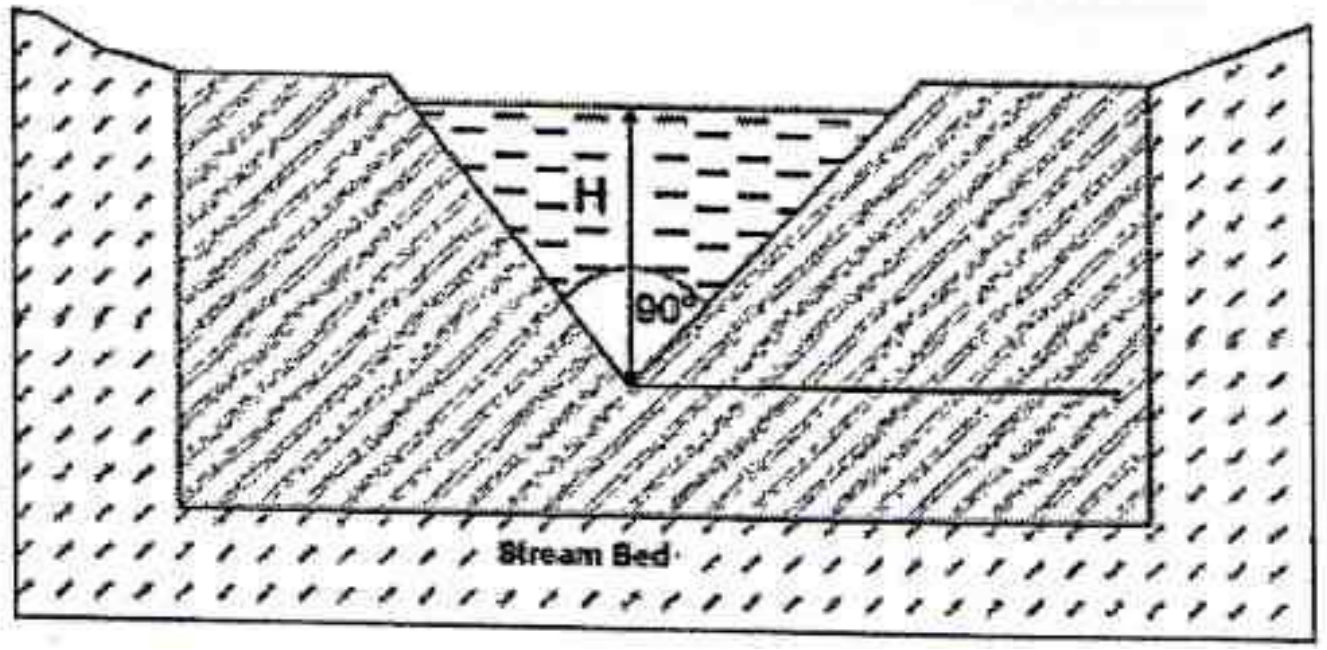
V - NOTCH

$Q = 1.417\ H^{5/2}$

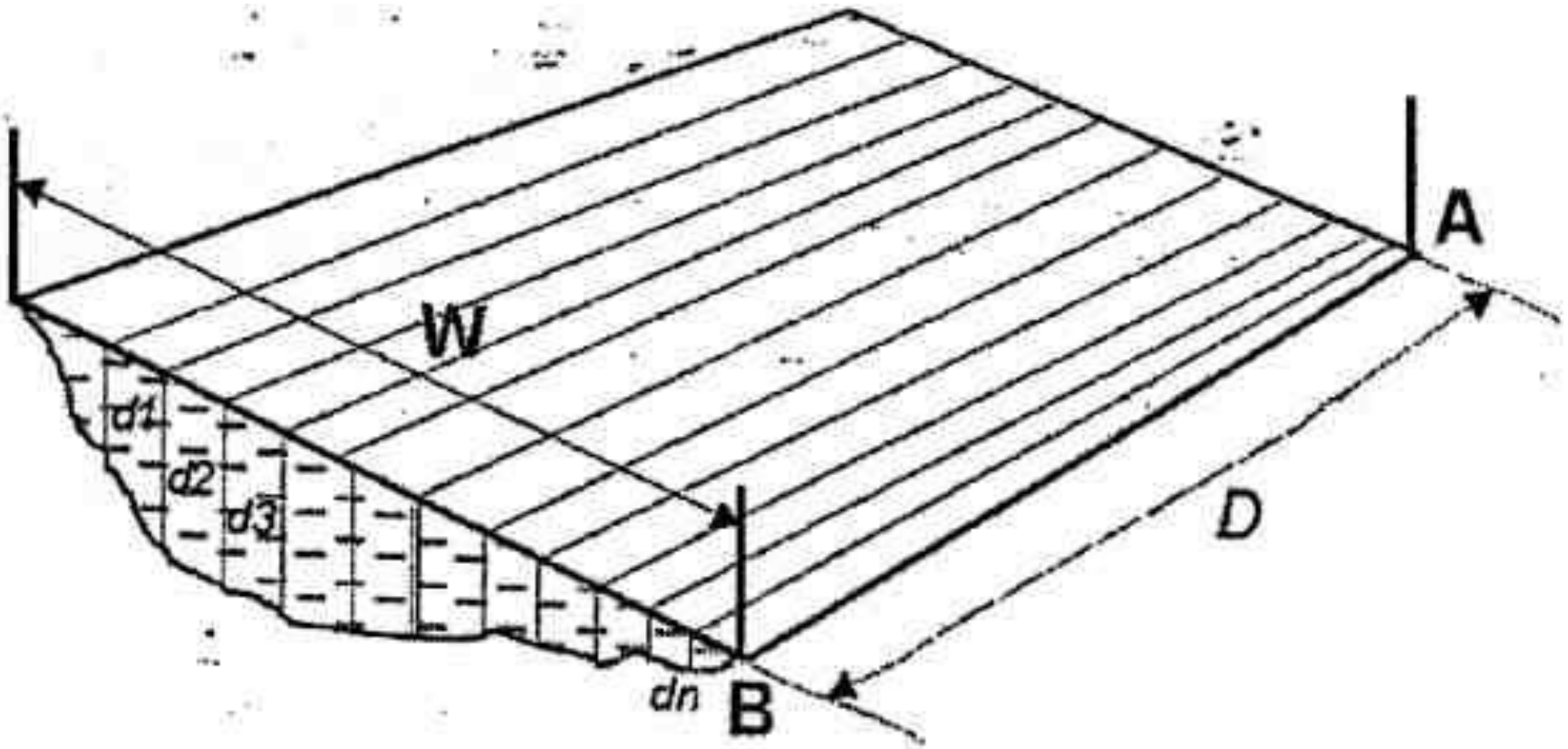
Where,

'Q' is discharge in cumecs

'H' is the height of water meters



AREA VELOCITY METHOD



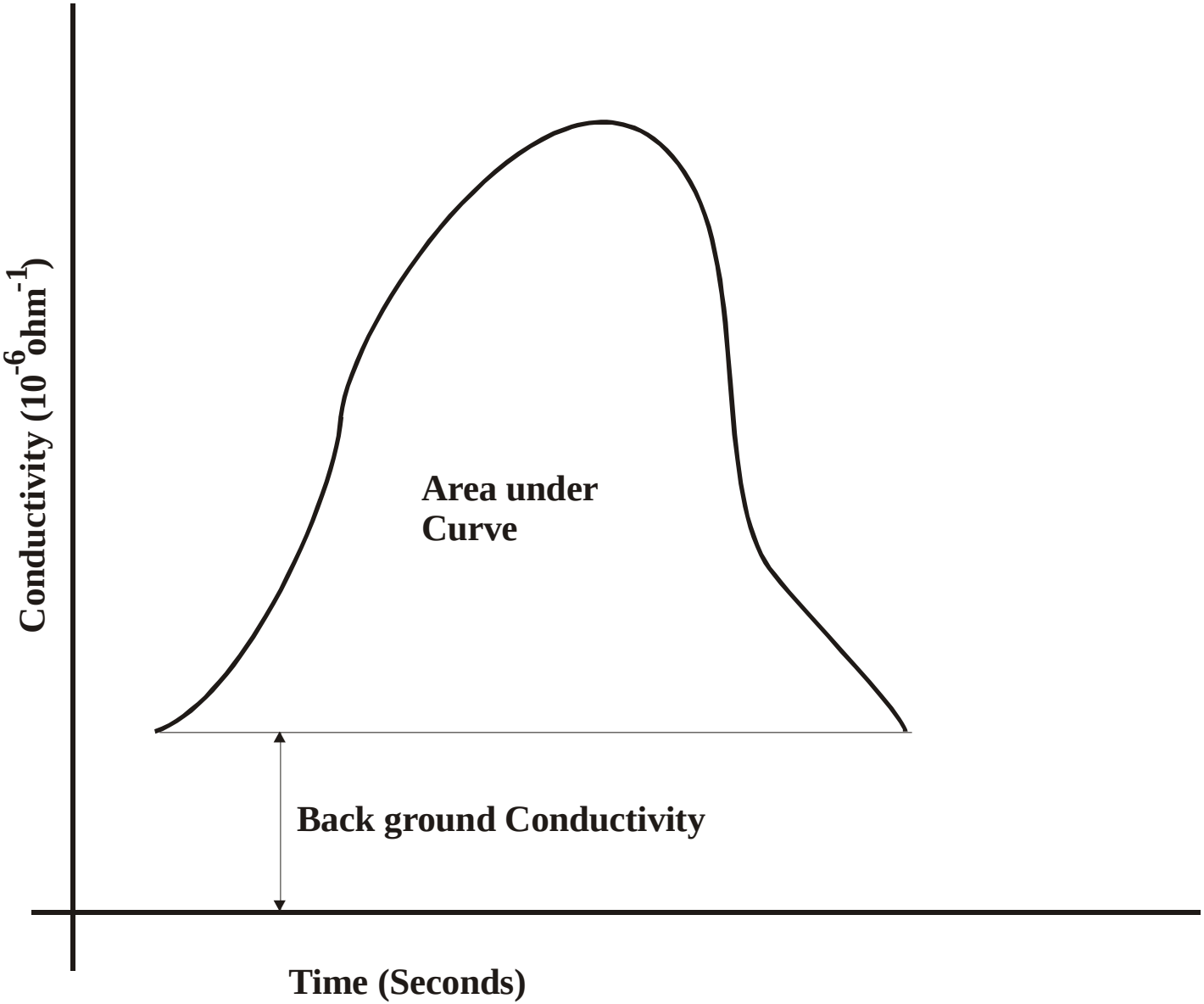
FLOW MEASUREMENT OF TURBULENT STREAM

- **Instrument – Flow Stream**
- **Range – Upto 4000 l/s**
- **Accuracy – 1%**
- **Principle – Conductivity of the water**
- **Q = M/(K x A) cumec**

  M = Mass of salt (Kg)

  K = Conversion factor ($Kg/m^3/ohm^{-1}$)

  A = Area under curve ($ohm^{-1}S$)


Conductivity (10^{-6}ohm^{-1})
Area under Curve
Back ground Conductivity
Time (Seconds)

SELECTION OF DISCHARGE MEASUREMENT SECTION & POURING POSITION

- Discharge measurement section should be turbulent with no stagnant pools (water velocity less than 0.1 m/s). The measuring position should be in moving but not fast flowing water

- The pouring position should be at least 25 times the width of stream at discharge measurement section and the flow should be highly turbulent for better mixing of salt solution.

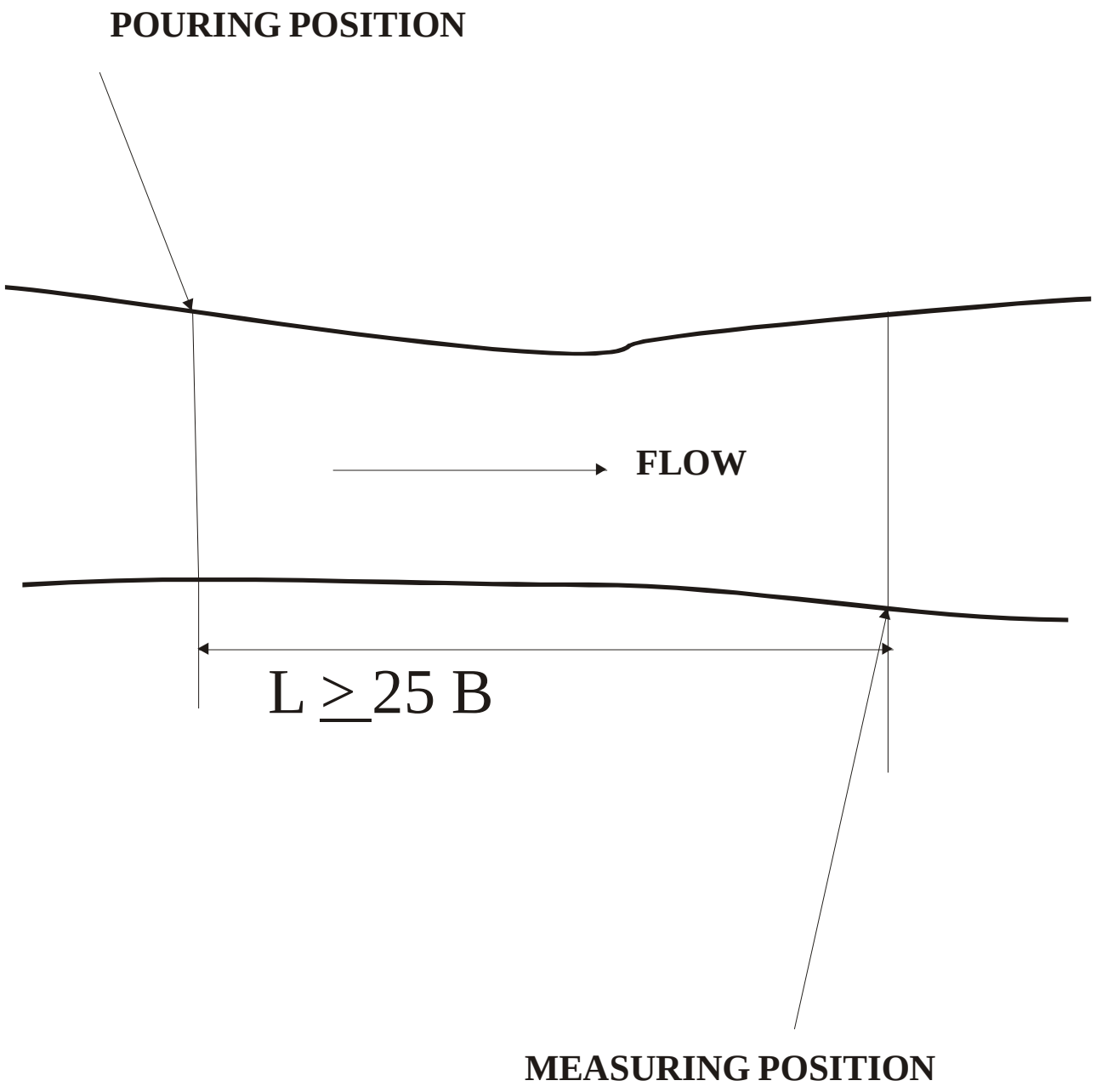
DETERMINATION OF QUANTITY OF SALT

- **Measure the Av. Width and Av. Depth of the discharge measurement section and multiply the two together.**

- **Select the quantity of salt to use from the Table.**

TABLE

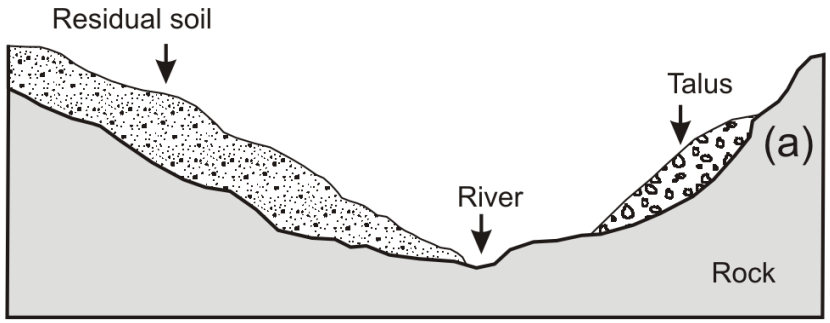
Width (m) X Depth (m)	Back Ground Conductivity		
	0-100 μs	100-500 μs	500-2000 μs
< 0.1	250 g	500 g	750 g
0.1 to 1.0	500 g	750 g	1000 g
> 1.0	1000 g	1500 g	1500 g

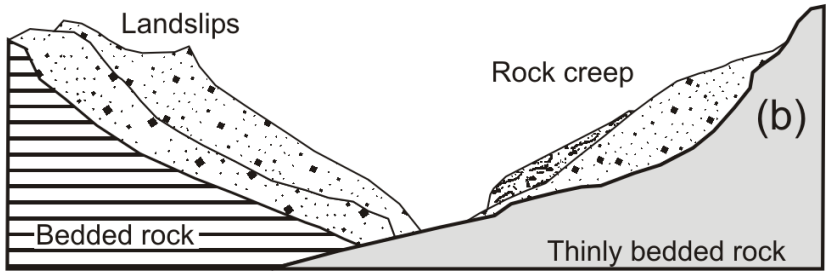

POURING POSITION
FLOW
L ≥ 25 B
MEASURING POSITION

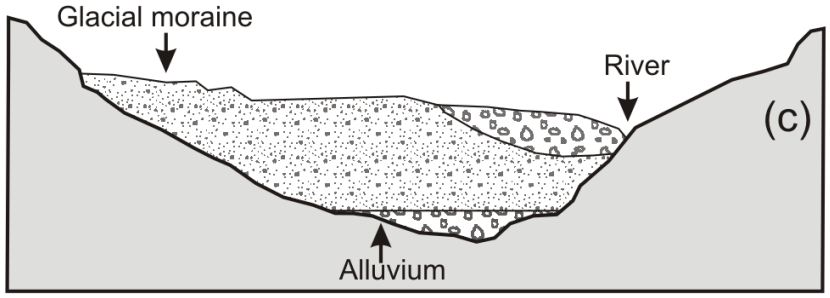
➢ STABILITY OF WEIRS

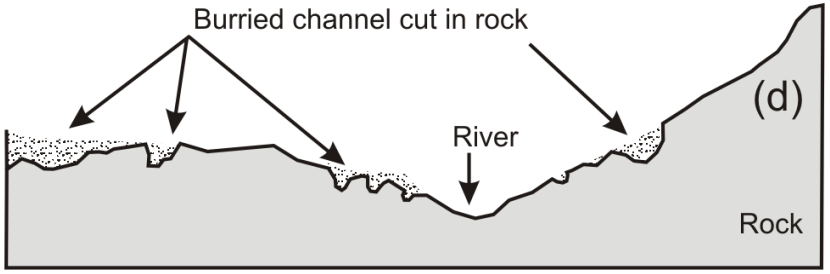
- The foundation mass should be impermeable (non-jointed, non-fractured and thoroughly crystalline igneous rocks, clay stones, massive sandstones and massive limestones) to avoid leakage.
- Narrow river valley is suited most for construction of weir
- Stable hill slopes attribute to the long life and stability of the reservoir.
- Sites should be selected carefully so as to be free from defects which could result to leakage from reservoirs
- Leakage may threat the safety and stability of the weir/dam.

DEFECTIVE FEATURES









LOAD DEMAND SURVEY
SOCIO-ECONOMIC SURVEY

- These surveys are required for isolated schemes
- Load assessment for – domestic, street light, commercial, institutions, industry and offices
- Present load demand assessment
- Growth in load demand based on socio-economic survey

METEOROLOGICAL SURVEY

- These surveys are required for large schemes
- Meteorological data such as rainfall, temperature, snow cover may be available with IMD Pune.
- Assessment of catchment area
- River slope
- Land use

CONSTRUCTION MATERIAL SURVEY

- Major requirement of materials is for cement, coarse aggregate, fine aggregate, bricks, stones, steel, timber, fabricated steel items

POWER EVACUATION LINE SURVEY

MUCK DISPOSAL AREA SURVEY

ENVIRONMENTAL SURVEY

- These surveys are required for large schemes more than 25 MW capacity. However, it is required if scheme is in reserve forest area.
- Affect of foundation and submergence after the creation of reservoir.
- Impact of deforestation.
- Scaring or defacing of natural surrounding, especially in the region of borrow pits and quarry sites.
- Preservation of cultural and ancient relics.
- Affect on stream flow.
- Change of water quality/ (organise matter content, temperature, dissolved solids contents etc.)
- EIA and EMP reports preparation

DURING AND FOR EXECUTION STAGE

- Sub soil exploration/geo-technical investigation for knowing soil parameters for structural designs
- Setting of the pillars with levels for controls of levels for excavation and structure
- Testing of construction material

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Thank you