Stream flow estimation
&
Rainfall –Runoff relationship

Run off

Run off can be described as the part of the water cycle that flows over land as surface water instead of being absorbed into groundwater or evaporating.

Three types of run off :-

- Surface runoff
- Interflow runoff
- Base flow runoff

Total Runoff = Surface runoff (including sub-surface runoff) + Base flow

Surface Runoff

It is that portion of rainfall, which enters the stream immediately after the rainfall.

Sub surface (interflow) Runoff

That part of rainfall, which first enters into the soil and moves laterally without joining the water-table to the streams, rivers or oceans, is known as sub-surface runoff or inter flow. it takes very little time to reach the river or channel in comparison to ground water.

Base flow (ground water flow)

It is delayed flow, part of rainfall, which after falling on the ground surface, infiltrates into the soil and meets to the water-table; and flow to the streams, oceans etc. It takes a long time to join the rivers or oceans, say for as years.

Channel runoff (streamflow)

It is the flow of water in streams and other channels. The discharge of water flowing in a channel is measured using stream gauges or can be estimated by the Manning equation. It is measured in units of discharge (m3/s). Stream flow rate determined by Q= V/T

Stream flow measurement is done by :-

stage measurement ,velocity measurement, discharge measurement

The direct methods of measurement of stream discharge include:

a. Area velocity methods
b. Dilution techniques
c. Electromagnetic method
d. Ultrasonic method

indirect methods are:-

slope area method (Manning eq.)

hydraulic structure

Manual gauges

Stage measurement is carried out using staff gauge

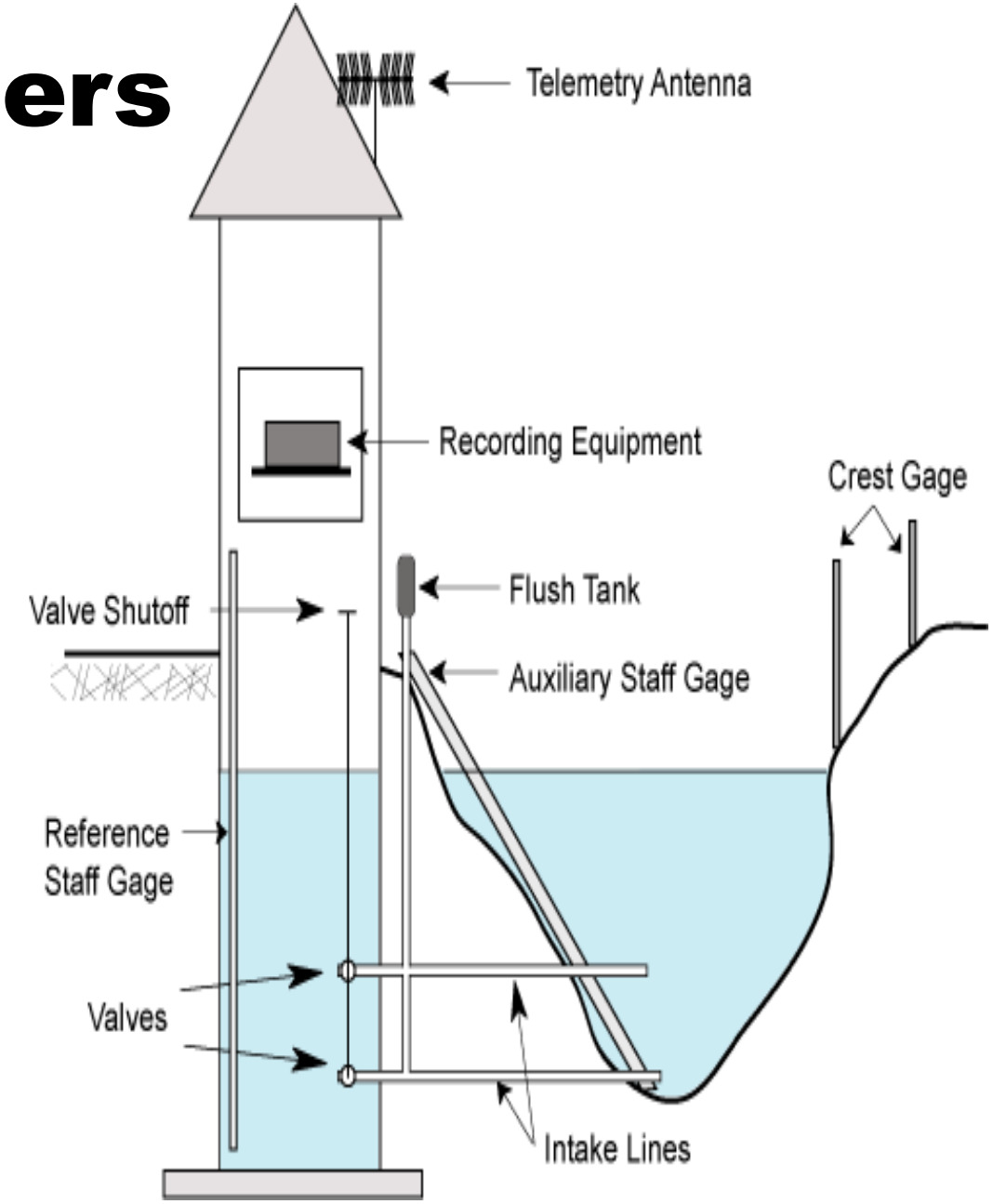
(manual gauge) The manual gauge is fixed to a structure like

bridge abutment, pier. It should be vertical with no inclination,

the markings should be clear.

Automatic stage recorders

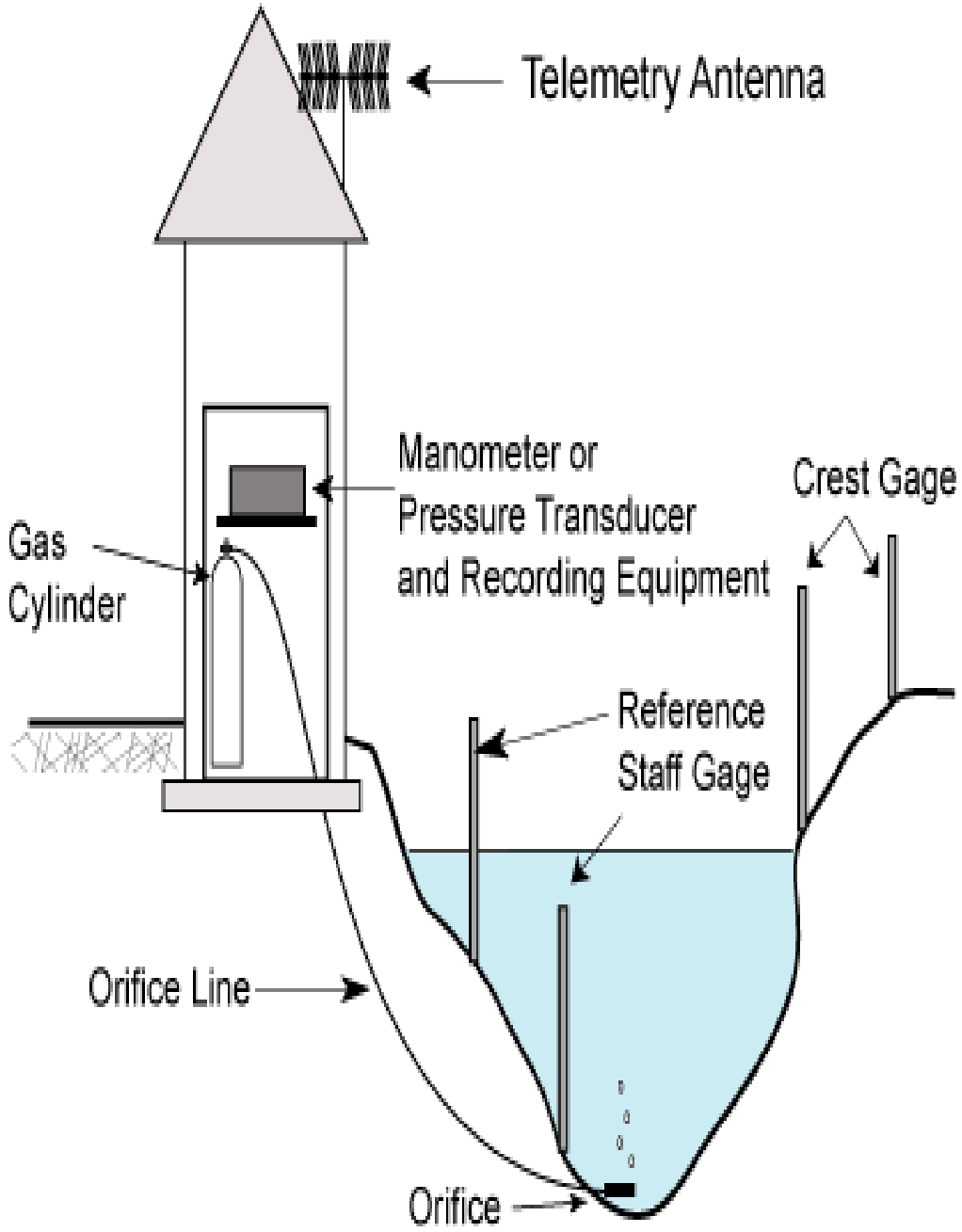
A float gauge recorder is typically housed in a stilling well. The float is balanced with a counter weight over a pulley system which is attached to a recorder. The displacement of the float due to change in water surface elevation causes an angular displacement in the pulley, which causes movement in the recorder. The recorder records stage versus time data continuously. the stage recorder is placed above the highest water level that may be reached at that site



Bubble gauge type recorder is used in which case compressed air or gas bubble is released through an outlet placed at the bottom of the stream. The advantage of such recorders is that it does not need a stilling well arrangement and the recorder assembly can be placed far away from the stream.

Stage data (stage hydrograph) is in the form of stage against chronological time..

Important in design of hydraulic structures, flood warning and flood protection work.



Measurement of velocity

Velocity can be measured directly, using a flowmeter (essentially a speedometer for water

Current meters :- it essentially consist of a rotating element which rotates due to the reaction of the stream current with an angular velocity proportional to the stream velocity.

it is used to measure velocity at a point across the cross section of the stream

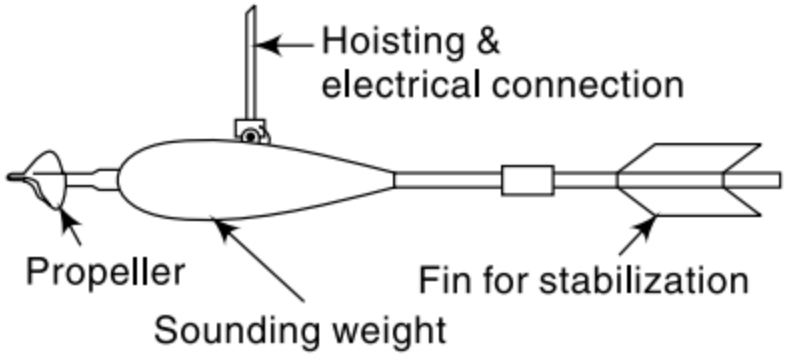
Two types of current meters :- vertical axis meters & horizontal axis meters

The vertical axis current meter consists of a series of conical cups mounted on a vertical axis .The conical cups fill with water and start rotating, this helps in the stream velocity measurement.

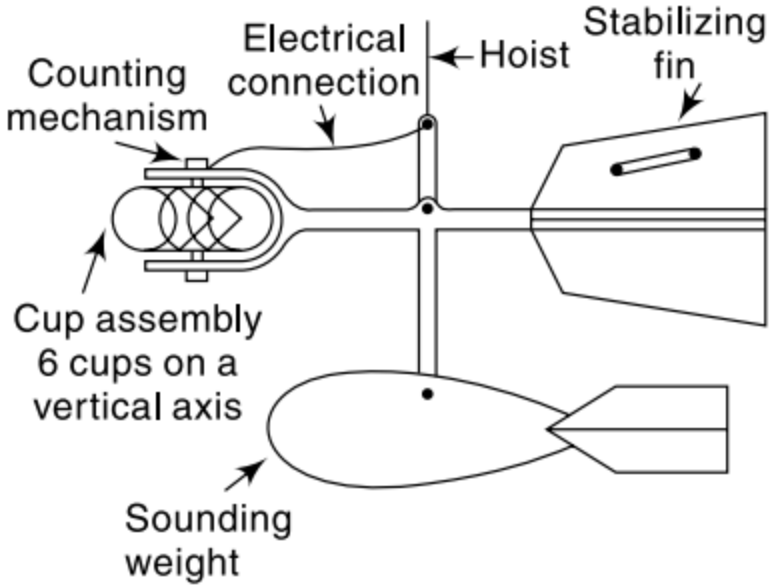
Horizontal axis meters consist of a propeller mounted at the end of horizontal shaft. It have a provision to count the number of revolutions in a known interval of time. This is accomplished by making & breaking of an electric circuit either mechanically or electro-magnetically at each revolution of the shaft. Revolutions per second is calculated by counting the number of such signals in a known interval of time.

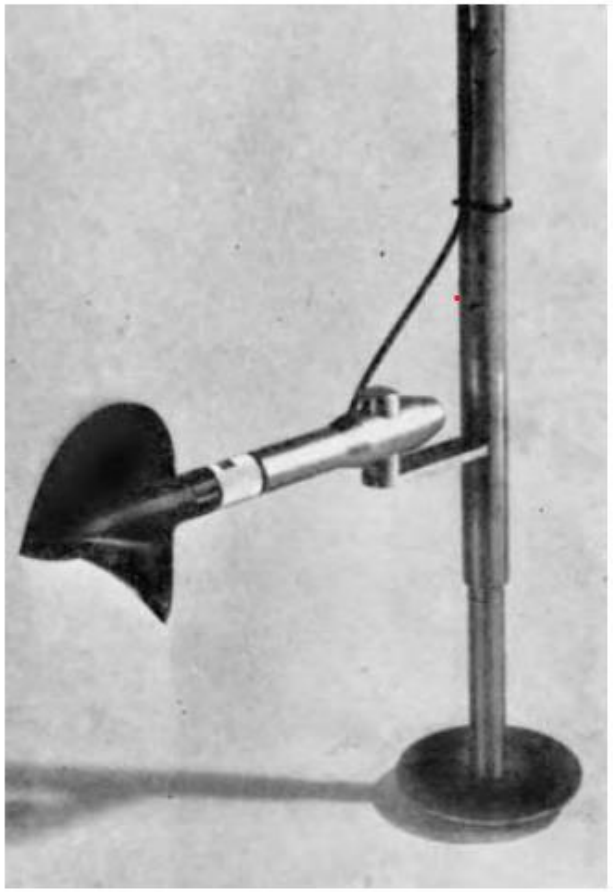
Horizontal current meter

CURRENT METER



vertical current meter





Area velocity method

- To determine the discharge of the stream at the selected cross-sectional area otherwise called the gauging site.
- The stream is divided into sections & at each of these sub sections the average velocity (distance/time)(by current meter mainly)is measured.
- the area of the sub section is determined by measuring the depth and the width of the subsection. The discharge (Q=V*A) at each of these subsections is the cross-sectional area multiplied by the average velocity at the sub section .
- The discharge estimation at the gauging site is the summation of all these individual discharges. Discharge is the volume of water flowing through the stream or river at a certain time.

Q= AV

Q = discharge (m3 /s) (cumec)

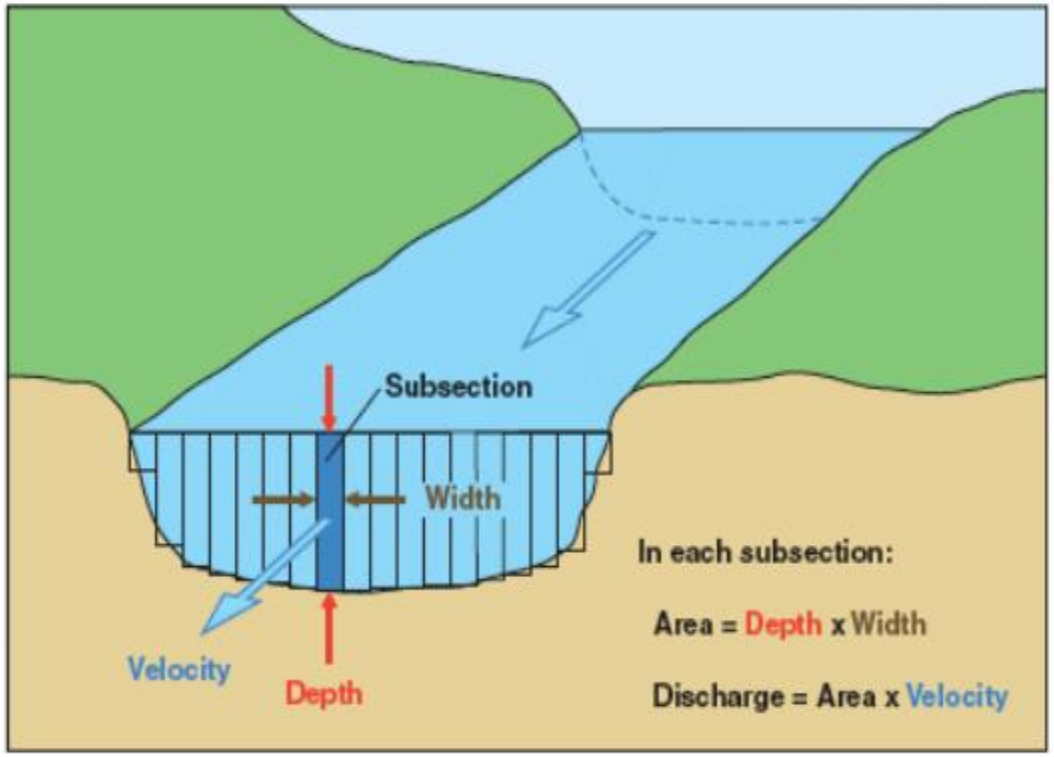
A = cross sectional area (m2)

V = velocity (m/s)

Rating curve

plots the discharge measured by area velocity method on the y axis and the measured stage depth at the gauging station on the x axis.

Hydrograph :-plots discharge of river over time

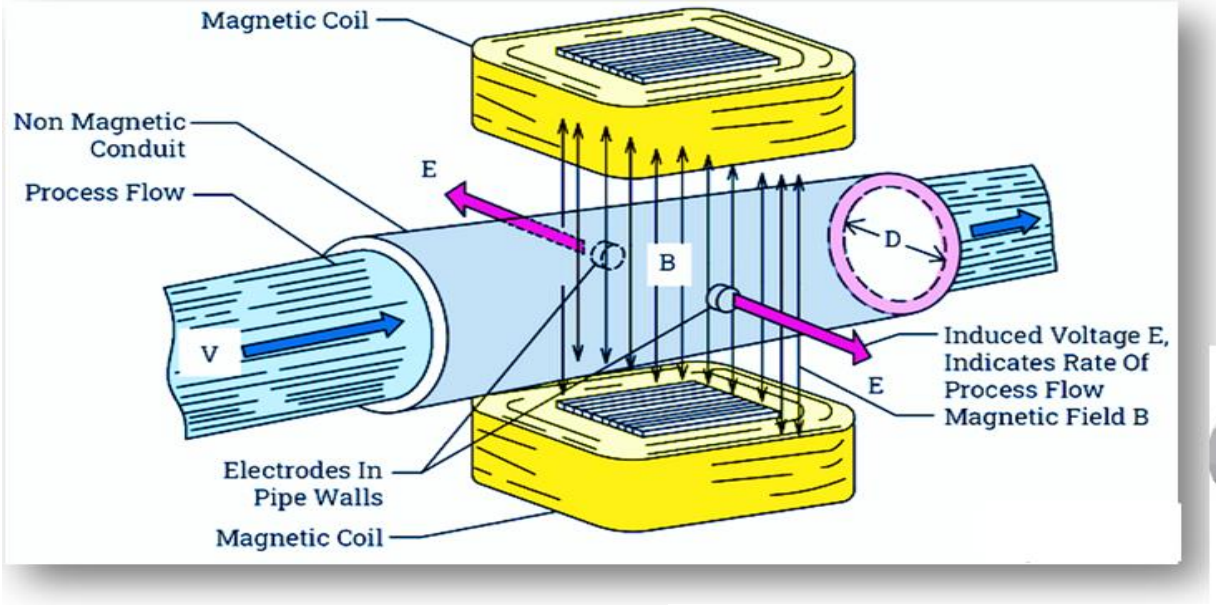


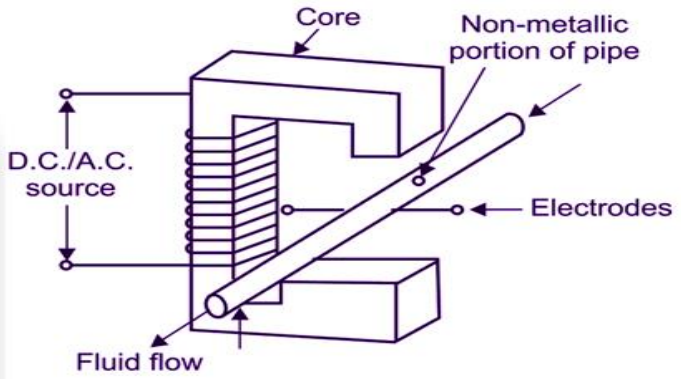
Dilution technique of stream flow

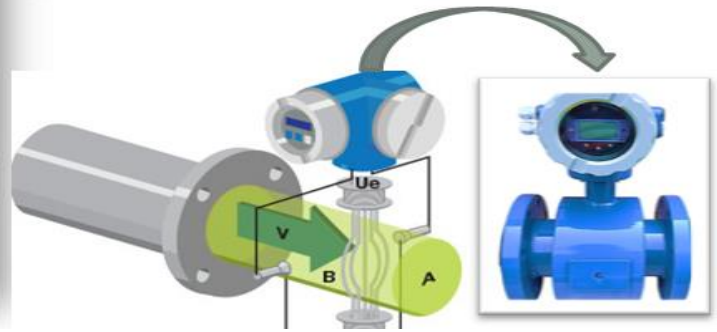
- It depends on continuity principle.
- Methods:- Sudden injection & constant rate injection method.
- It uses tracers which may be chemicals (NaCl, Na2Cr2o7), fluorescent dyes(rhodamine-WT) or radioactive materials(Br-82, Na-24,I-132). An initial high quantity of tracer is mixed in a small discharge and then the concentration of the diluted quantity is measured at another section using steady state continuity equation.

electromagnetic flow meter is used to measure flows in tidal streams/channels where is fluctuation in quantity and direction of flow. The minimum detectable velocity in this case is 0.005m/s. They can also be used for cross sections which are disturbed by weed growth and sedimentation

ElectricalWorkbook

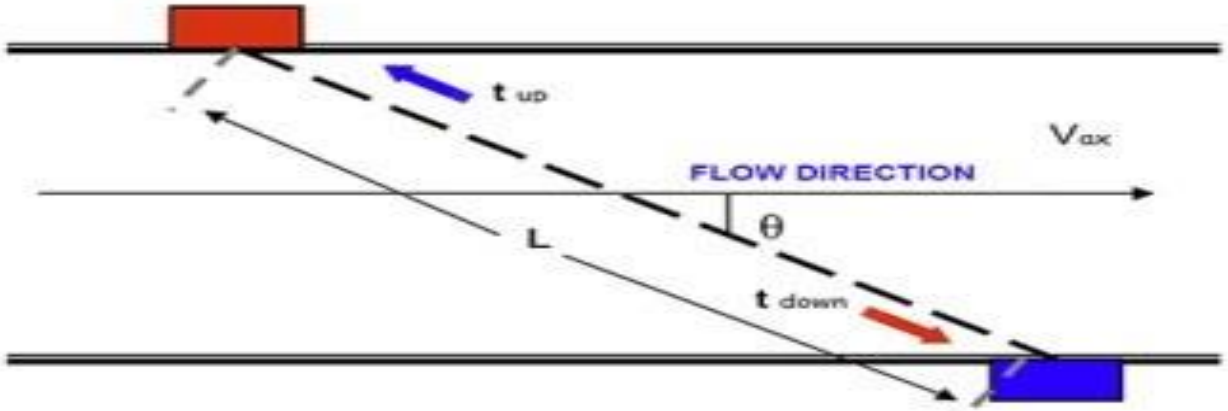






Upstream Transducer

Ultrasonic



Downstream Transducer

Ultrasonic method of velocity measurement of flow

It uses two transducers fixed at two banks of the river or channel, receive and send ultrasonic signals. Time taken from one end to another is different.

In one case the component of flow velocity in the direction of the sound waves is added to the velocity of sound, while other bank the flow velocity component is subtracted.

The difference in the two velocity components since it can be measured, and the width of the stream is known, the velocity of flow can be determined.

Used for unstable cross sections, which have fluctuating weed growth sections, high suspended solids in flow and there is rapid change in magnitude and direction of flow.

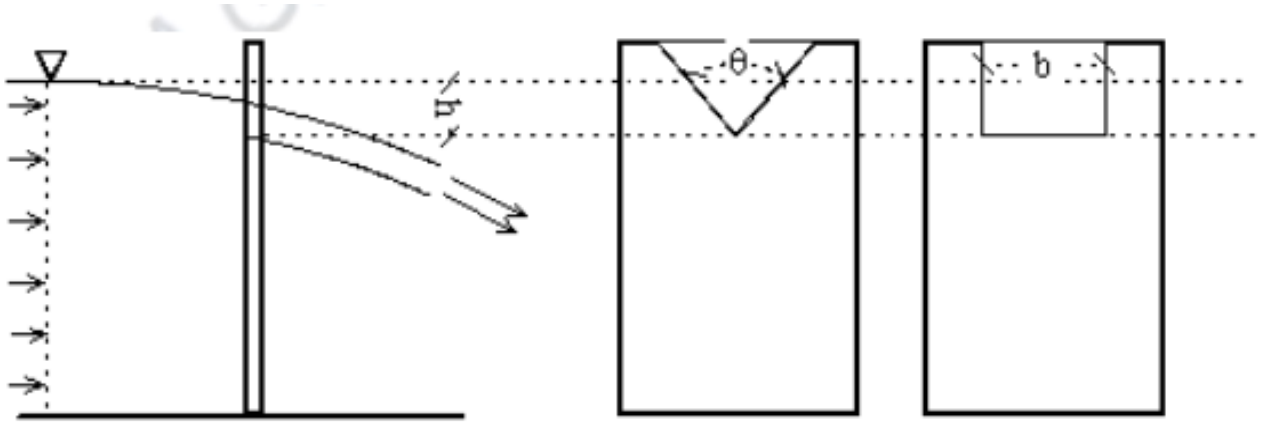
Stage discharge relationship (rating curve)

Measured value of discharge plotted against the corresponding stages

Indirect measurement of flow :- weirs

A weir is a small wall(thin steel plate , concrete & erosion resistant) constructed across the width of the stream to create an obstruction to flow to measure discharge.

Two types :- V notch type weir & rectangular weir



Rainfall runoff relationship

The rainfall-runoff relationship for any rainstorm depends on the dynamic interaction between rain intensity, soil infiltration and surface storage.

Runoff occurs whenever rain intensity exceeds the infiltration capacity of the soil

- runoff from a given rainstorm is a function of:
  i. rainfall intensity distribution and sequence, during a particular rainstorm event;
  ii. soil infiltration rates;
  iii. the soil surface storage capacity

Factors Affecting Runoff:

Climatic factors

Type of precipitation

Rainfall intensity

Duration of rainfall

Rainfall distribution

Direction , velocity of prevailing wind

Annual rainfall

physiographic factors

size of watershed

shape of watershed

slope of watershed

orientation of watershed

land use

soil moisture , type

Thank you