PUMPING TESTS

Analysis

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Interpretation of pumping test data

- Pumping test data are interpreted for:
  - Estimating aquifer properties like Transmissivity and Storativity.
  - Estimating well characteristics, especially the well yield or specific capacity.

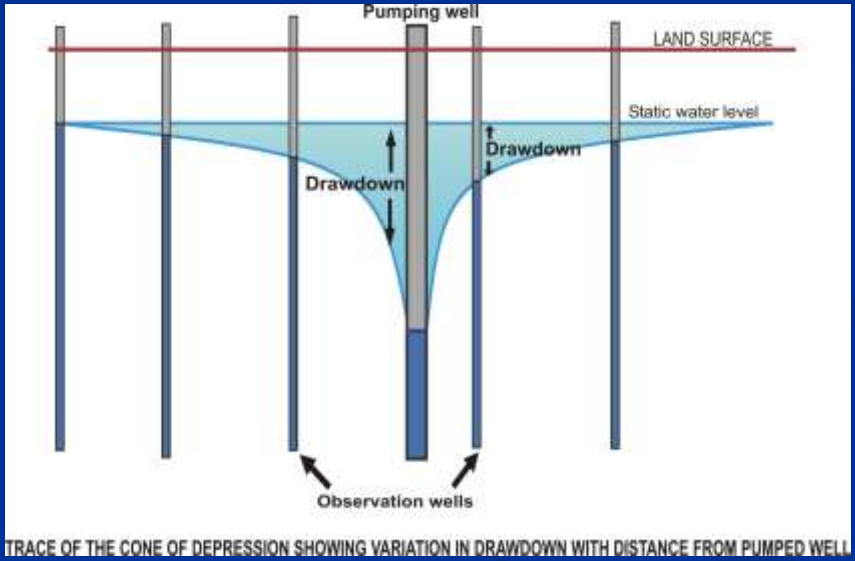
Aquifer performance tests

- Observations in pumping and observation wells.

- In an aquifer performance test, the drawdown measurements are made with respect to fixed time intervals. The pump discharge is also checked several times during pumping period. The recovery measurements, after the pump being shutoff, are also made at fixed intervals.

- The main aim this test is to estimate aquifer characteristics i.e. Transmissivity and Storativity.

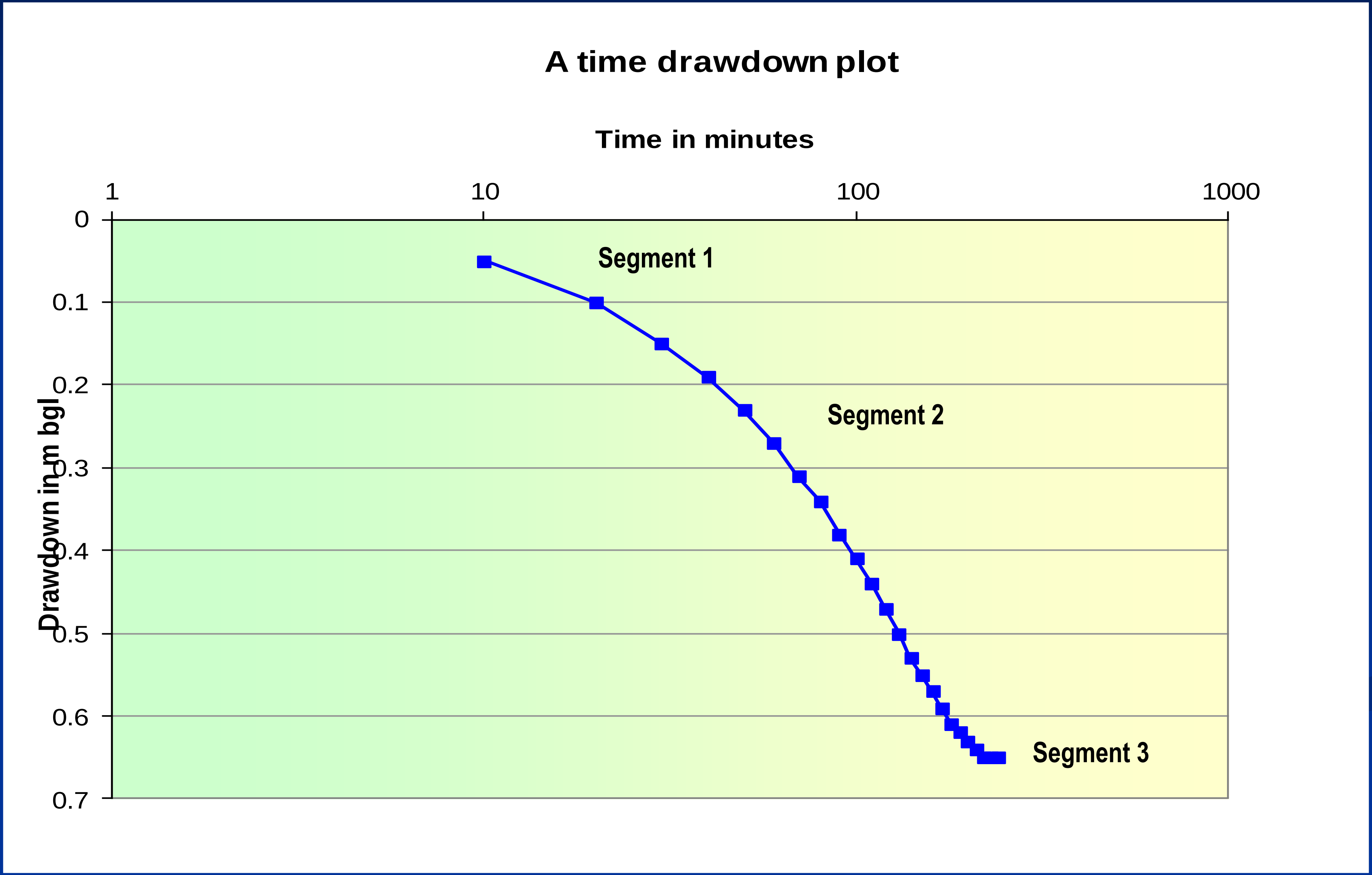
- There are many methods of interpreting pumping test data. These are given in various text books on groundwater.



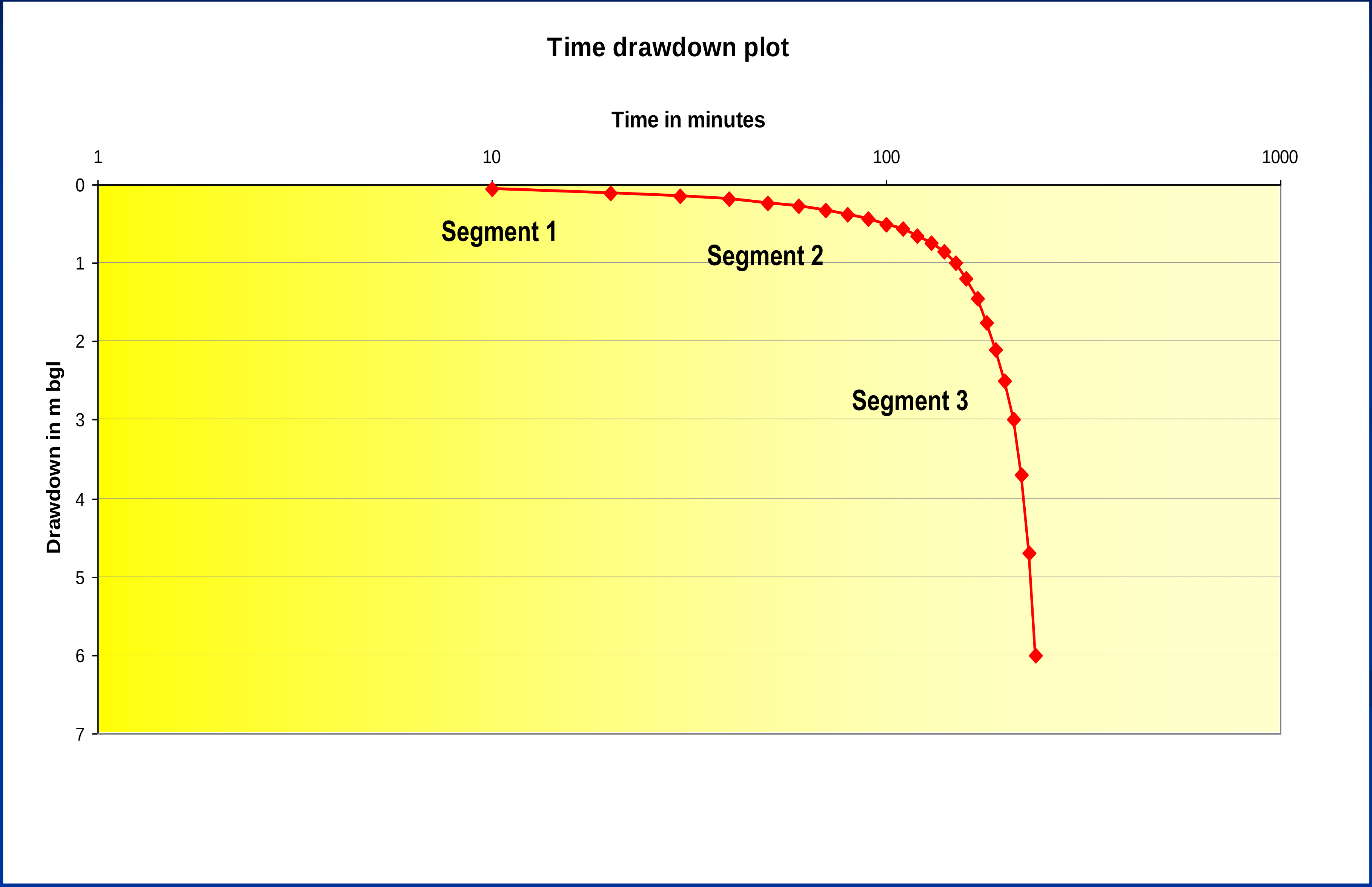
An example of interpreting aquifer test data

- We will consider a very simple graphical method given by Cooper and Jacob (1964) to estimate T and S.
- The water level in pumping well / observation wells (below MP) is plotted against time since pumping started **t** on semi logarithmic graph paper:
  - Water level (as drawdown s) on arithmetic scale and time on log scale.
    - The first few points reflect the effect of well storage (segment 1)
    - Segment 2 indicates the effect of contribution from aquifer in the form of inflow (in pumping well during pumping)
    - In case of observation well data, points on a straight line indicate the effect of dewatering of the aquifer in the form of drawdown.
    - The third segment which also falls on a straight line, may indicate:
      - A gentler slope as compared with segment 2 indicating an increase in aquifer contribution (q) as compared to the pump discharge Q. This indicates that the aquifer is receiving recharge from some external source during pumping (may be river, lake, canal etc.), often leading to a steady state condition.
      - Sometimes the slope of the segment 3 steepens as compared with segment 2. This indicates the limited extent of the aquifer, showing sudden increase in the rate of drawdown (i.e. aquifer contribution q is much smaller than the pump discharge Q).

A time-drawdown plot… STEADY STATE



A time-drawdown plot… DEWATERED WELL



Transmissivity from the Cooper Jacob formula

- The Transmissivity can be obtained using the semilog graph (as given in the above examples) and the following procedure:
  - The value of Δs which is the drawdown over ONE LOG CYCLE of time "t" is calculated.
  - Segment 2 is generally used to obtain the Δs value used in following equation
- $T = (2.303 \times Q) / 4\prod\Delta s$ is the original equation where the final equation is
- $T = (264 \times Q) / \Delta s$
  - Here, T is directly obtained in m^2/day directly
  - Q= Pump discharge in m^3 per min
  - Δs= slope of segment 2 over one log cycle of time t expressed in metres.

- If Q (pump discharge) is common for both the cases and is equal to 1 m^3/min, we have
  - For graph 1 (steady state), Δs is approximately 0.5 m

  $T = (264 \times 1) / 0.5$

  i.e. $T = 528\ m^2/day$

  - For graph 2 (unsteady state), Δs is approximately 15 m

  $T = (264 \times 1) / 15$

  i.e. $T = 17.6\ m^2/day$

Storativity from the Cooper Jacob formula

- For Storativity S the data of drawdown in OBs well at distance "r" from the pumping well is necessary.
- Storativity S is given by the equation
- $S=2.25\ Tt_0 / r^2$ where,
  - T= Transmissivity in m^2 / min
  - t_0= intercept of straight line on the time axis
  - r = distance of observation well from pumping well

(S is given in fraction)

For an observation well at a distance of 50 m from the pumping well:

- Graph 1 shows t_0 of about 60 min and therefore:

S= 2.25(528/1440)60 / 2500

i.e. <u>S= 0.0198</u>

- Graph 2 shows t_0 of about 40 min and therefore:

S= 2.25(17.6/1440)40 / 2500

i.e. <u>S= 0.000049</u>

Well tests

- Observations are made in the *pumping well* itself (no observation wells)
- The main aim of the well test is to estimate the yielding capacity of the well or capacity to derive water form the aquifer known as **"specific capacity"**
- in case of a bore well, the water stored in the form of water column is small in quantity. Therefore, during pumping, initially the stored water is pumped out and later on the pump discharge is entirely composed of water derived from the aquifer. Under such condition the capacity of the bore well to derive water from the aquifer i.e. specific capacity of bore well is given by equation
- Specific capacity $C = Q / s$ where
  - Q= discharge of the pump in Liters per minute (Lpm)
  - s= drawdown in pumping well after certain time has lapsed

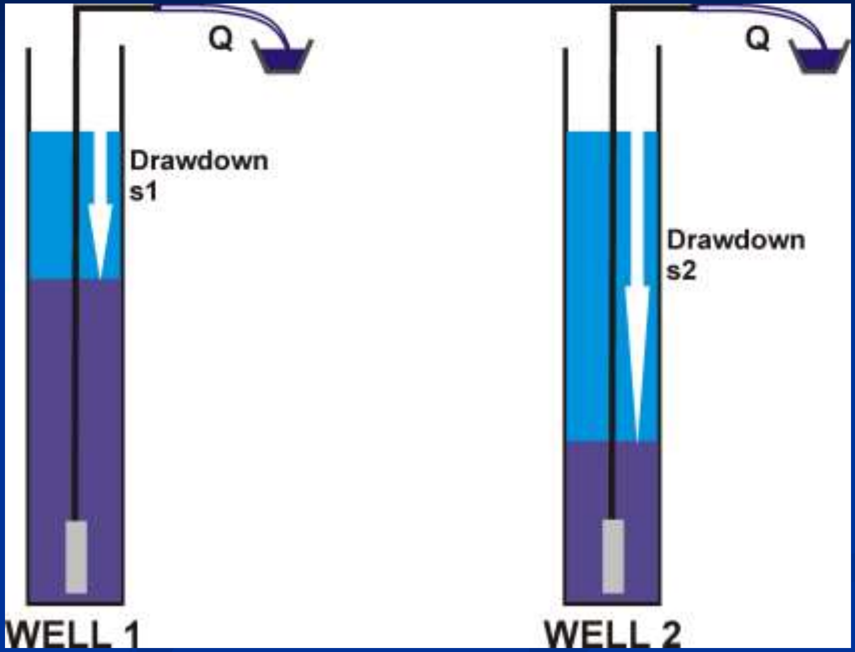
- Therefore, specific capacity is **discharge per unit of drawdown**.
  - For example, a bore well is pumped at rate Q= 500 lpm for 2 hours with a resultant drawdown s= 5m,
  - Specific capacity of the bore well is $C = Q/s = 500$ lpm / 5 m
  - i.e. 100 lpm per metre of drawdown

What does specific capacity mean…

The specific capacity value of C= 100 lpm /m implies:

- that the same borewell will yield about 6000 litres in one hour, resulting in a drawdown of 1 m.
- It will yield about 12000 litres in two hours with a drawdown of about 2 m.
- If it is pumped at the rate of 200 lpm, the well will draw down to 2 m in one hour.

Thus, in case of a bore well, the specific capacity can be used to predict the level of drawdown for different pump discharge rates.



Which bore well has a greater Specific capacity?

Which is larger:
Q/s1 or Q/s2?

Solution

Well 1 has a greater specific capacity than well 2.

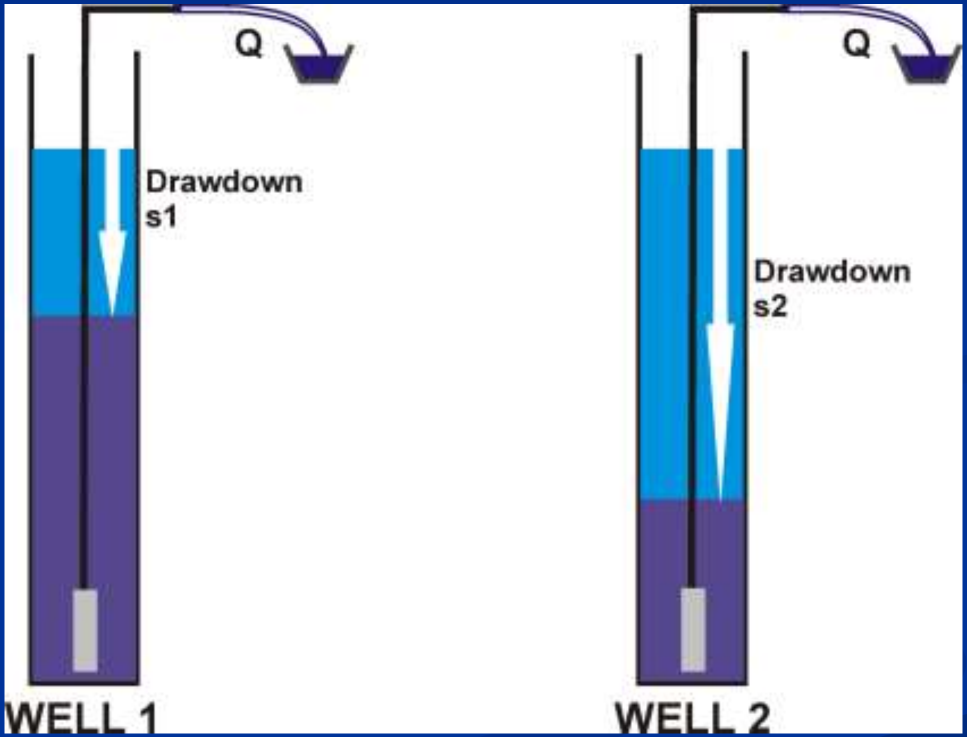
If Q= 100 lpm

s1= 5m

s2= 10m then

C of well 1= 20 lpm/m

C of well 2= 10 lpm/m



Specific capacity of a large diameter dug well

- In case of large diameter dug wells (which are common in most parts of India), the specific capacity estimation method used for bore wells is not applicable.
- The amount of water stored in a dugwell is much larger as compared to that in a bore well. Therefore, the pump discharge in case of dug well is composed of water partly derived from:
  - the well storage and
  - water derived from the aquifer.
- The resultant drawdown in a dug well is also due to the effect of the above two factors.
- Therefore, the normal method of using the ratio *pump discharge / drawdown* may not exactly represent the capacity to derive water from the aquifer per unit of drawdown.

Slichter's method of estimating the specific capacity (yield) of a dug well

- In order to estimate the specific capacity of a dug well, the (recuperation) recovery data is used for analysis.
- Recovery data does not involve the effect of well storage on pump discharge (as the pump is shut off) and contains the effect of the contribution of water from the aquifer only. This effect is in the form of rise in water level in pumping well.

- The specific capacity is calculated using Slichter's Recovery Formula:

$C = (2.303(A / t')) (\log_{10} (s1/ s2))$

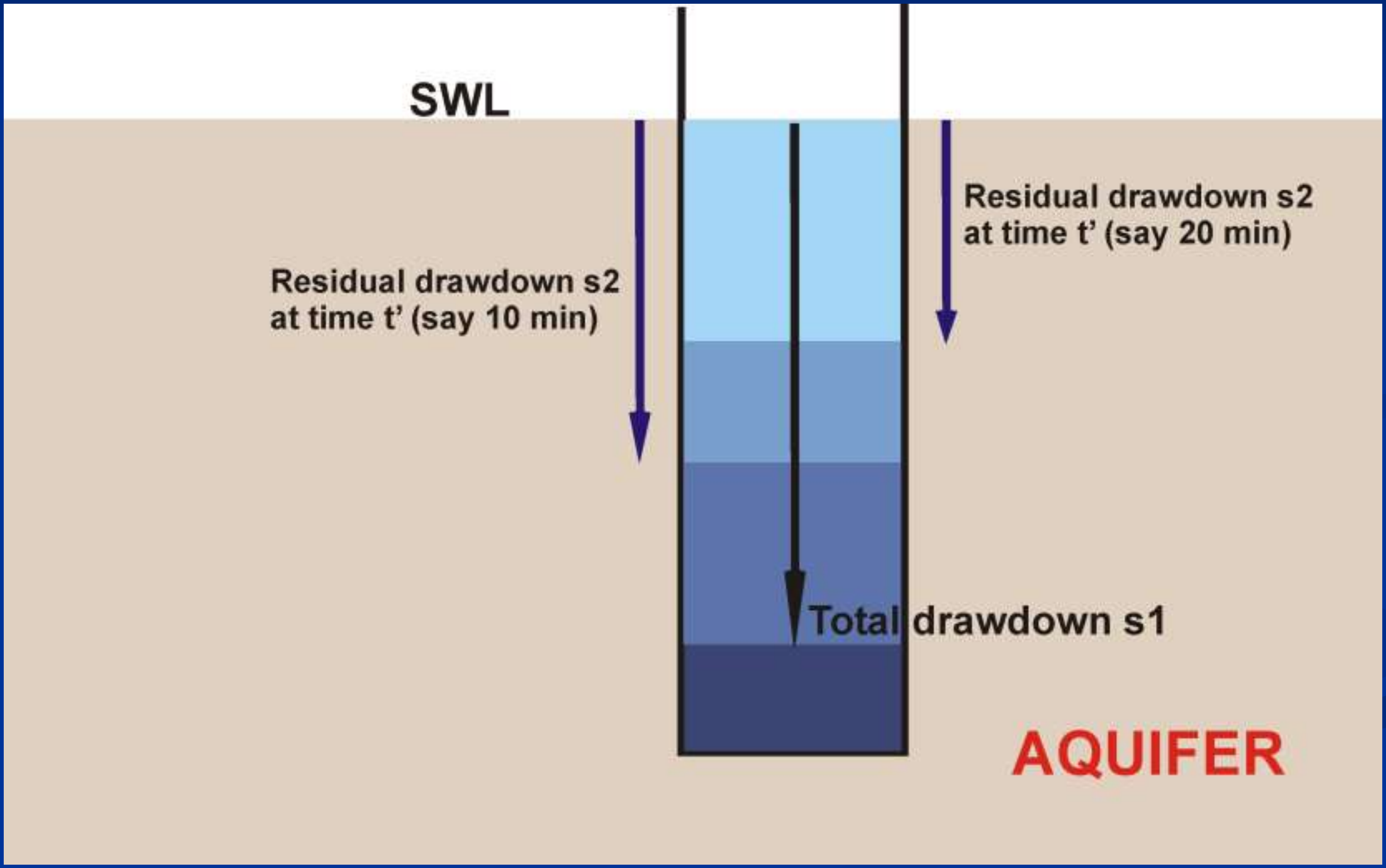
where

- C= Specific capacity of dug well in m^3/min per metre of drawdown or lpm/m of drawdown
- A= cross sectional area $\prod r^2$ (in m^2)
- t'= time since pumping stopped in minutes
- s1= total drawdown in meters
- s2= residual drawdown values in meters at respective time values since pumping stopped (t')

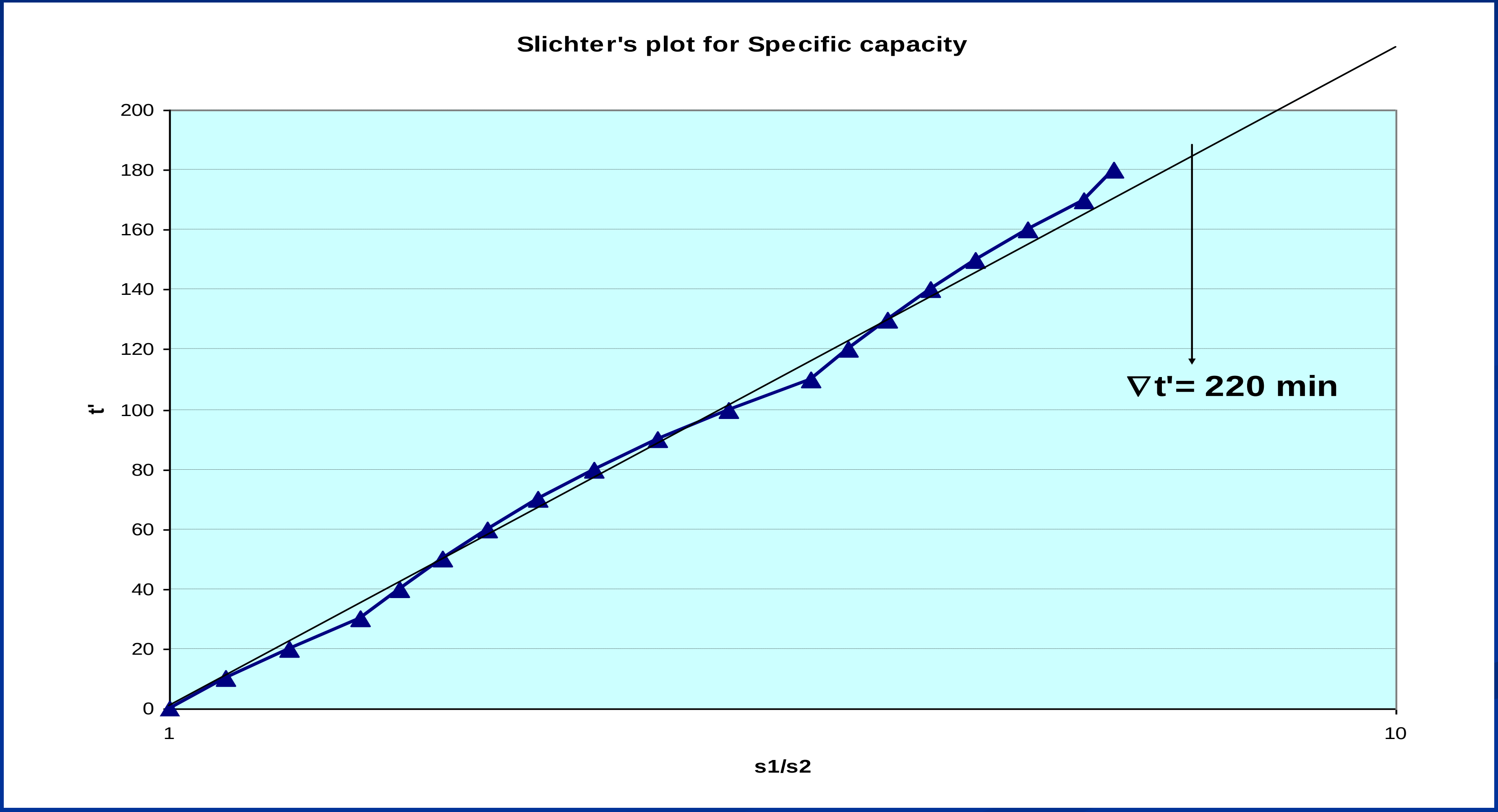
Method for estimating specific capacity of dug well using the Slichter method

- Measure the total drawdown in the well (s1) at the end of pumping.
- Similar to a drawdown test, measure the water level rise in the well and estimate the residual drawdown s2 at different times (t').
- Residual drawdown (s1) can be estimated by subtracting the rise in water level over a fixed time from the total drawdown (s1)
- The ratio s1/s2 is calculated for each value of time t' for which values of s2 are measured.
- A graph of t' values (Y-axis) is plotted against the ratio s1 / s2 (X-axis) on a semilog paper.
- A straight line is plotted through these points and the slope of the line (change in the value of t over one log-cycle of the ratio (s1/s2) is estimated.

Drawdown and residual drawdown measurement during recovery



Specific capacity data



Specific capacity example

- Using the plot (previous slide) the equation:

  $C = (2.303(A / t'))/(\log_{10}(s1/s2))$

  reduces to

  $C = (2.303A)/\nabla t'$

  Where $\nabla t'$ = change in the value of t' over one log cycle of the ratio s1/s2

- If the cross sectional area (A) of the well= 20 m^2
- $\nabla t'$= 220 minutes

Specific capacity can be calculated as:

$C = (2.303(20)/220)1000$

C= 209.36 lpm/m of drawdown

Thank you for your patience.