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PUMPING TESTS

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Some common questions from well-owners about aquifers…

In hydrogeology, once the aquifers have been delineated it is necessary to find out how an aquifer will respond to pumping out the water from aquifer storage?

A well-user may be interested in knowing:

- How much water his well can supply?
- What should be the capacity of the pump to be fitted on his well?
- What is the range of Transmissivity and Storativity of the aquifer?

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A pumping test means pumping a well…

- In order to answer questions about the aquifer and wells tapping the aquifer, certain tests are conducted in the field, by pumping out water from a well

- The water table or potentiometric surface declines when we pump out the water from the aquifer storage. This is measured along with how much water is pumped out

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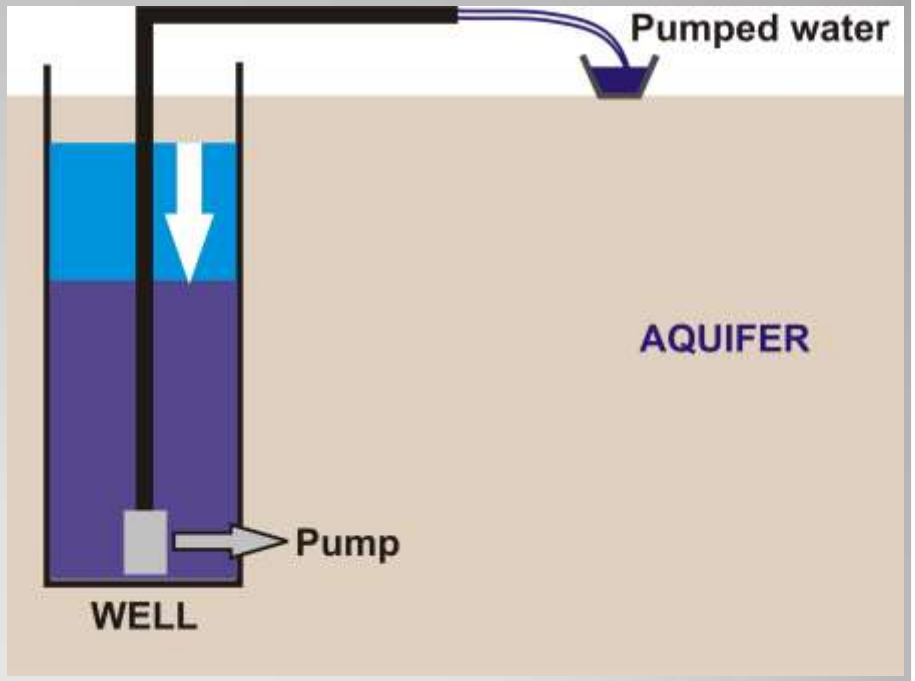
What is a pumping test?

Basic procedure of a pumping test involves:

- Water is pumped from a well (pumping well)
- Its impact on the pumping well as well as on the aquifer it taps is ascertained by
  - Observing the change in water levels in wells tapping the aquifer
  - Measuring how the rate at which the water is pumped out from the well



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Type of the pumping tests

Pumping tests are divided into two main types:

1. **Well test**
2. **Aquifer performance test**

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Well test

- In a well test, a well is pumped and observations are made in the pumping well only
- Here, **the well** is tested rather than the aquifer
- The aim of this test is to determine the *yield* of the well

Aquifer Performance Test

- Quantify the properties of the aquifer
- Observations are made in the pumping well as well as in observation wells around the pumping well
- The aim of this test is:
  - To estimate the performance of the aquifer
  - Estimate aquifer properties like Transmissivity and Storativity

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A pumping test requires equipment…

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Mechanics of pumping or Well Hydraulics

- What happens in a well being pumped and in the surrounding aquifer is described as "*mechanics of pumping*" or "*well hydraulics*"

- Prior to pumping, the water level in the aquifer including pumping well is referred to as *"static water level" (SWL)*

- SWL represents the level above which water in a well will not rise at any particular time because there is no recharge into or discharge from the aquifer storage

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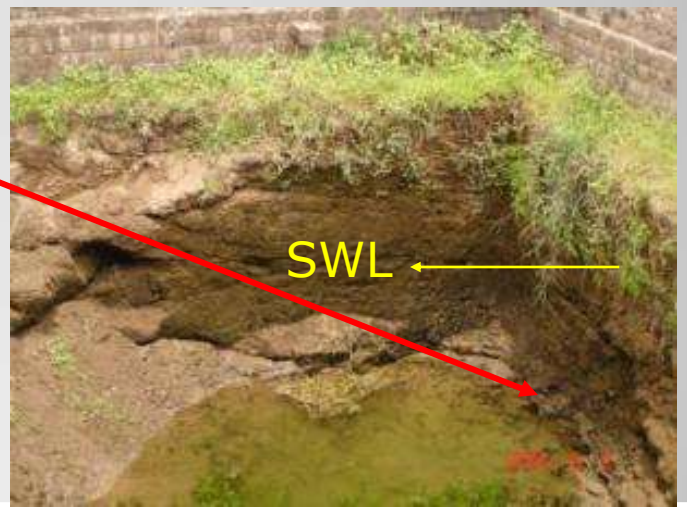
Static and Pumping Water Level

- When pumping begins, water levels in the pumping well and in wells nearby (observation wells) declines
- Any level measured during the process of pumping is called **pumping water level**
- Now, the pumping water level in the pumping well stands at a lower elevation (deeper) as compared with the water levels in the surrounding aquifer
- Such water level can be referred to as "Head"



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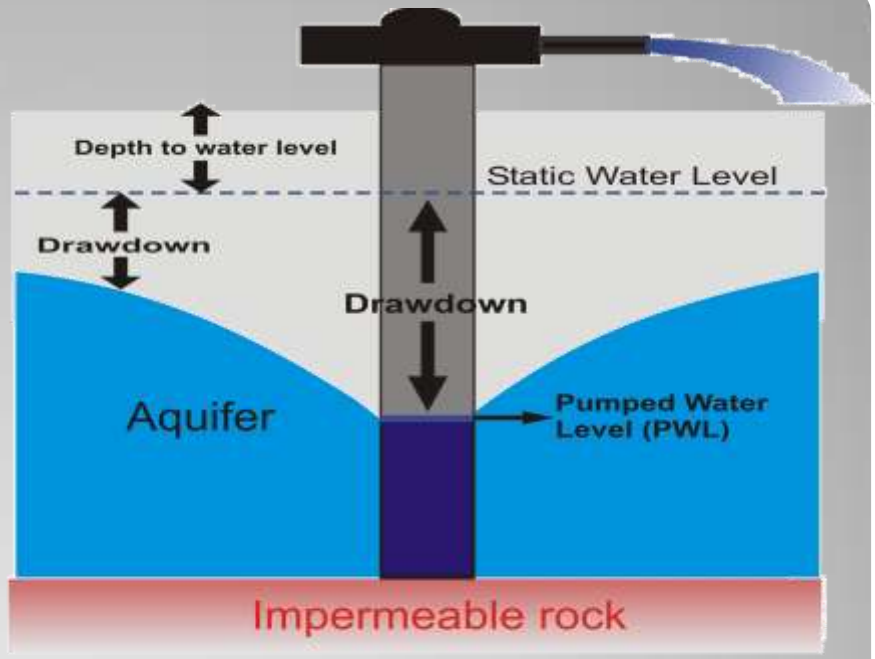
Hydraulic Gradient

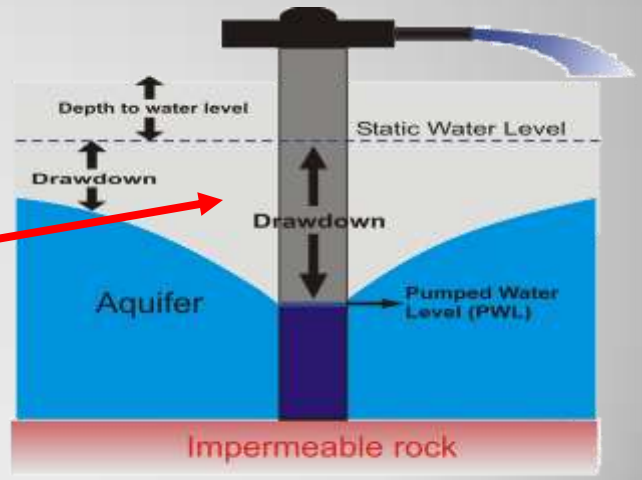
- A head difference exists between the pumping well and the surrounding aquifer
- Therefore, a hydraulic gradient is created from the surrounding aquifer towards the pumping well (according to Darcy's law - from **higher head** to **lower head**)
- Under the influence of this artificial hydraulic gradient the water stored in the aquifer surrounding the pumping well starts moving towards the pumping well and finally into the pumping well as *inflow* (***known as aquifer contribution "q"***)



TERMS RELATING TO WELL PERFORMANCE

Dewatering of aquifer

- As pumping continues, *inflow water* from the aquifer is also pumped out along with water stored in the pumping well
- More and more water is now derived from the aquifer dewatering the volume of the aquifer surrounding the pumping well
- Dewatering of aquifer volume (due to discharge from aquifer storage) results in lowering the water level (i.e. Head) in pumping well as well as over aquifer surface area where dewatering of openings under the hydraulic gradient has taken place



TERMS RELATING TO WELL PERFORMANCE

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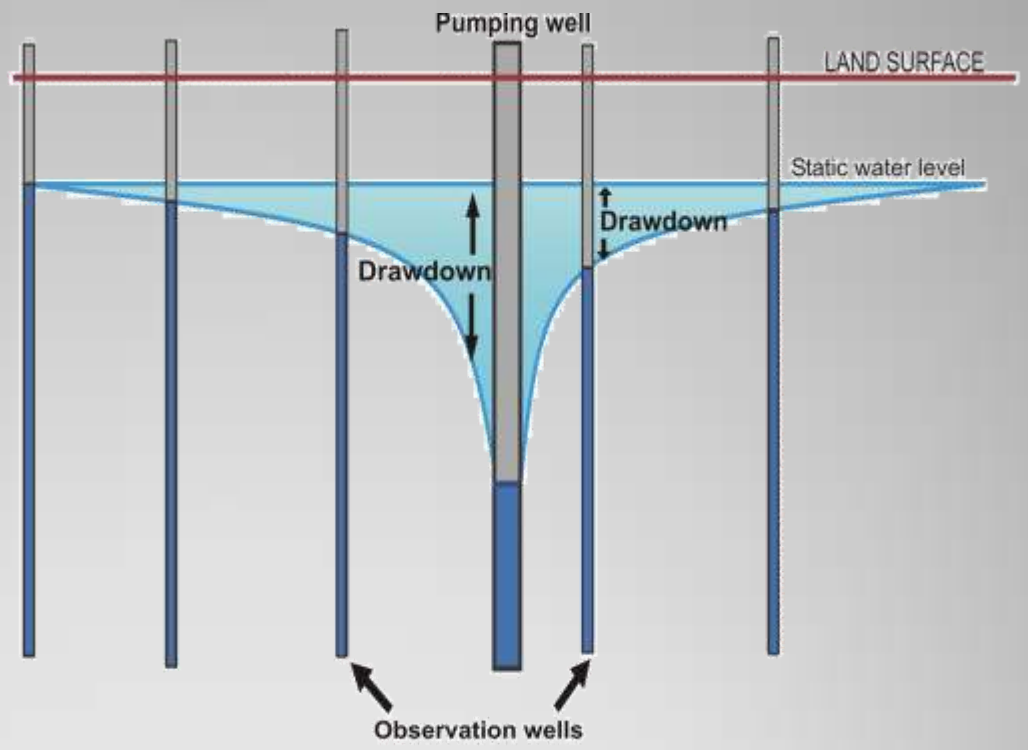
Drawdown

- Now, if we have observation wells surrounding the pumping well, the decline of water level will be reflected in these observation wells

- The difference between the static water level and the pumping water levels in different wells is known as "**drawdown**"



TRACE OF THE CONE OF DEPRESSION SHOWING VARIATION IN DRAWDOWN WITH DISTANCE FROM PUMPED WELL

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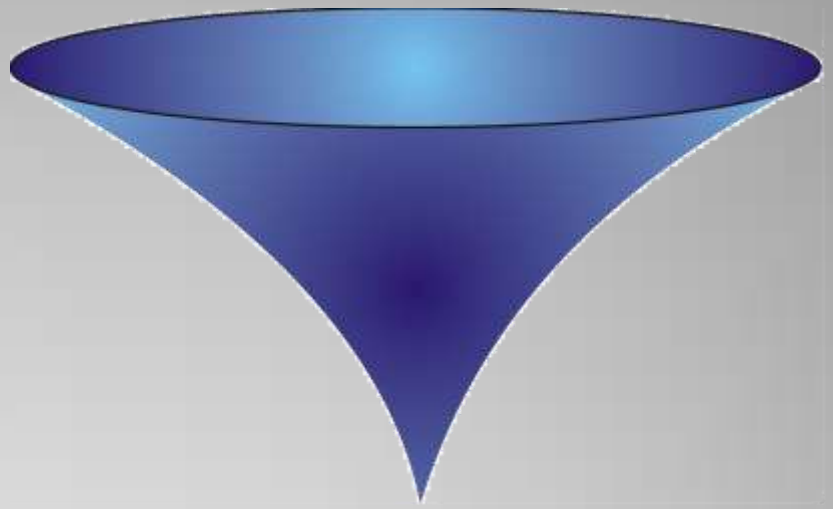
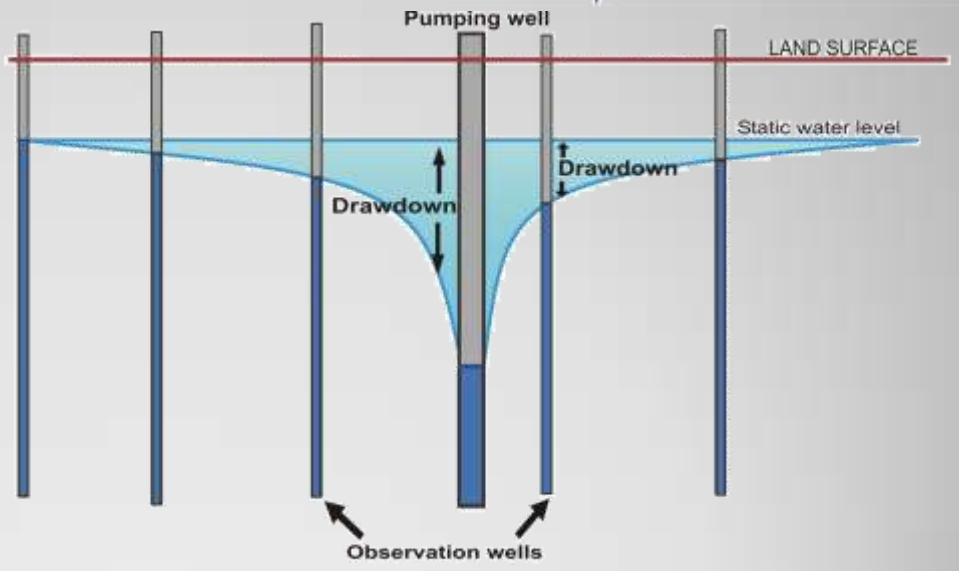
Cone of Depression

- A shape of an inversed cone results if you join the drawdown in the pumping and observation wells (i.e. head distribution within the aquifer)
- This inverted cone is called as **Cone of Depression**
- The cone of depression expands with continued pumping





TRACE OF THE CONE OF DEPRESSION SHOWING VARIATION IN DRAWDOWN WITH DISTANCE FROM PUMPED WELL

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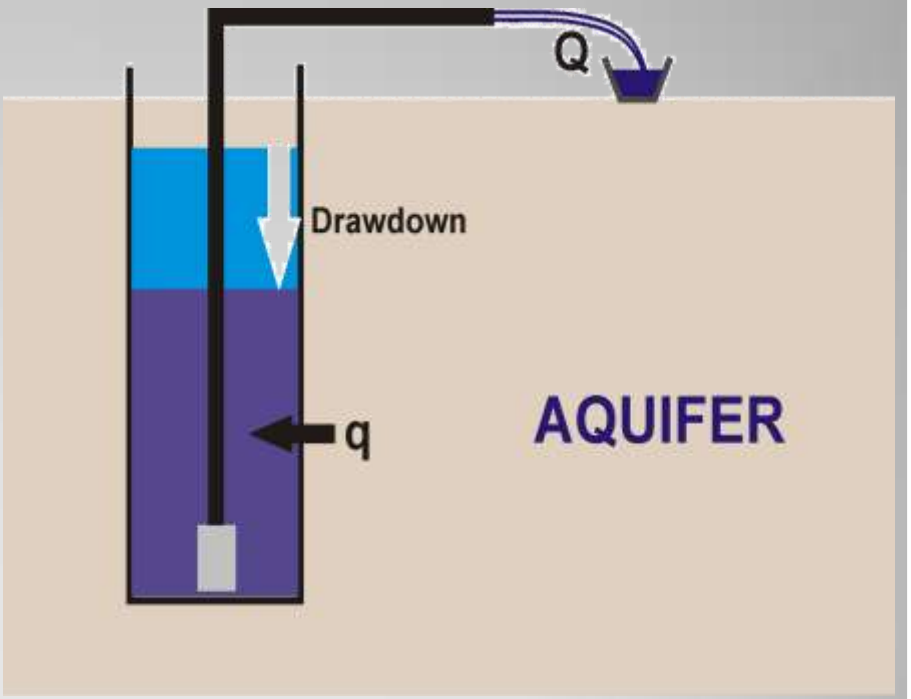
Aquifer contribution

The expansion of cone of depression depends upon:

- The rate of pumping- Q
- The aquifer contribution- q from the aquifer to the well (as inflows into the well)



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Drawdown depends upon quantity of inflow

- For instance,
  - if pump discharge Q > aquifer contribution q more and more portion of aquifer volume is dewatered, indicated by continuous drawdown in pumping well as well as in the observation wells
  - if Q nearly matches with q i.e. Q = q, drawdown in the pumping well and in the observations wells remains nearly constant (as the inflow from aquifer "q" is in excess or equal to the pump discharge Q) indicated by no further deepening of cone of depression in the pumping well

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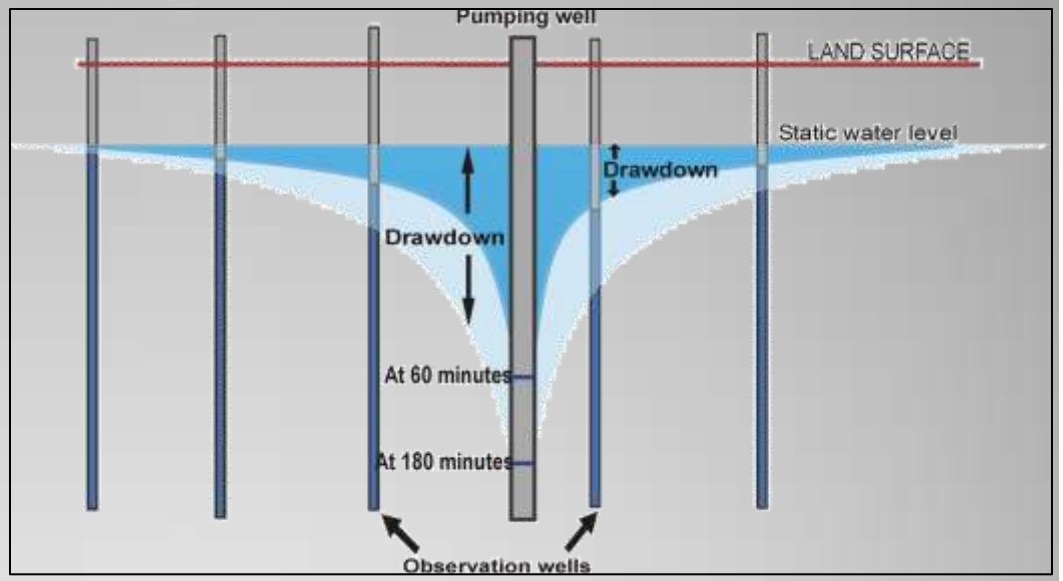
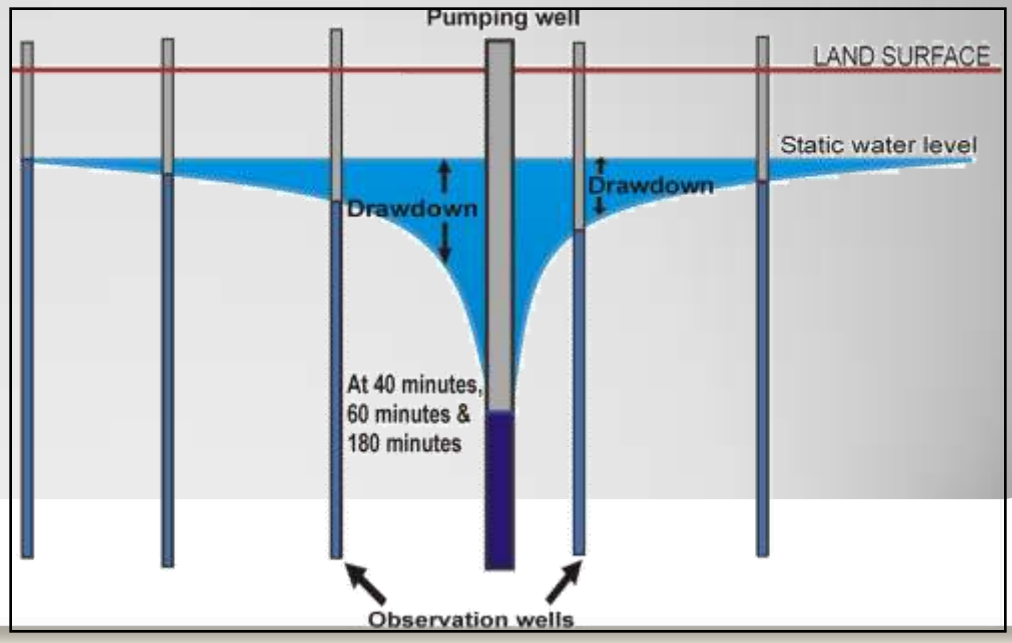
Relation between the outflow and inflow

Q=Outflow (pumping)

q=Inflow (aquifer water flowing into well)

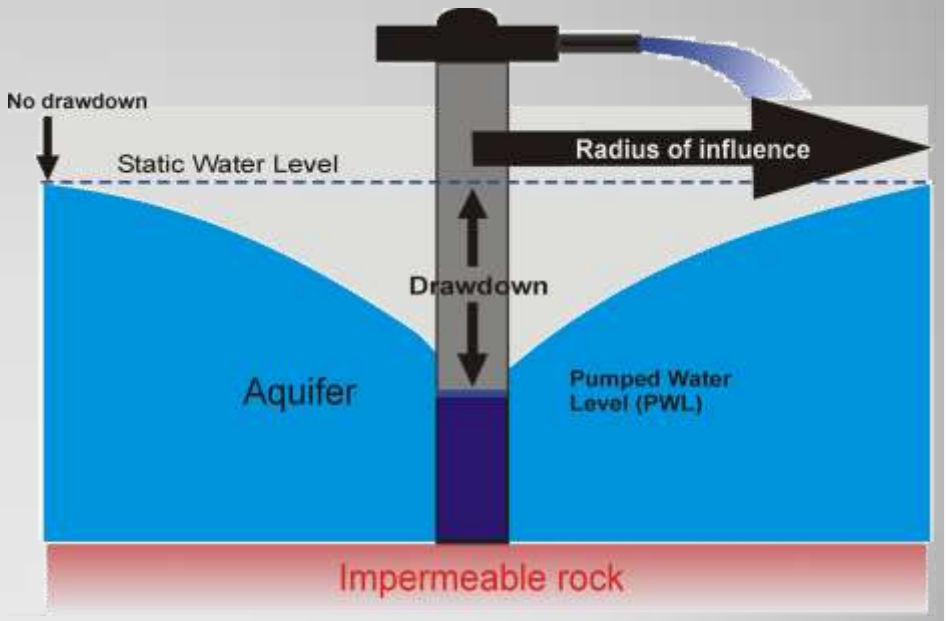
- Then
  - Q > q implies INEQUILIBRIUM or UNSTEADY STATE CONDITION
  - Q = OR < q implies EQUILIBRIUM or STEADY STATE CONDITION





Pumped Water Level & Drawdown

- The distance from centre of pumping well to periphery of the cone of depression is *known as "radius of influence"*
- After the pumping is stopped, the level of water in pumped well is known as "pumped water level"
- The difference in static water level and pumped water level is known as "Total Drawdown" in this condition



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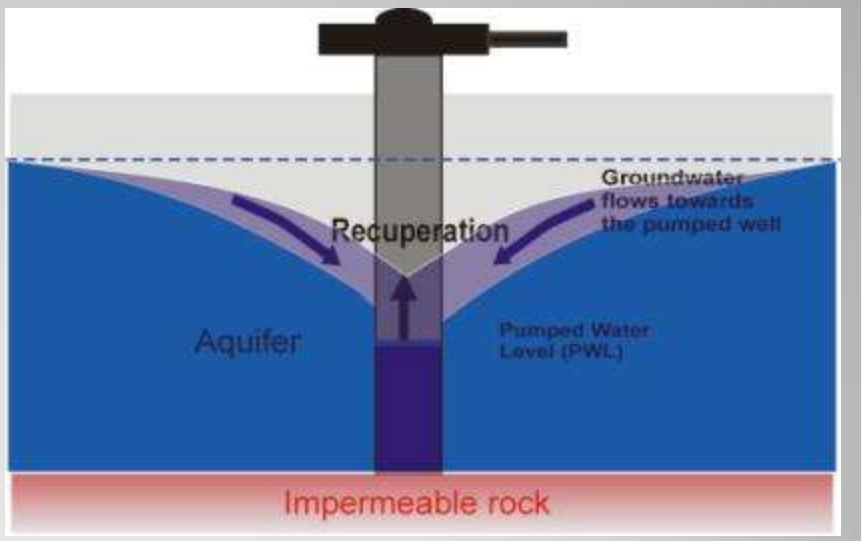
Recuperation or recovery

- Water from the surrounding aquifer continues to flow towards the pumping well under the influence of the (artificial) hydraulic gradient towards the pumping well
- After pumping is stopped, due to continued aquifer contribution **q**, water level in the pumping well as well as in the aquifer surrounding the pumping well rises
- This is because the portion of the aquifer which was earlier dewatered during pumping starts resaturating due the water inflowing towards the pumping well (indicated by rise in water level in pumping and observation wells)
- This process is known as "recovery or recuperation"



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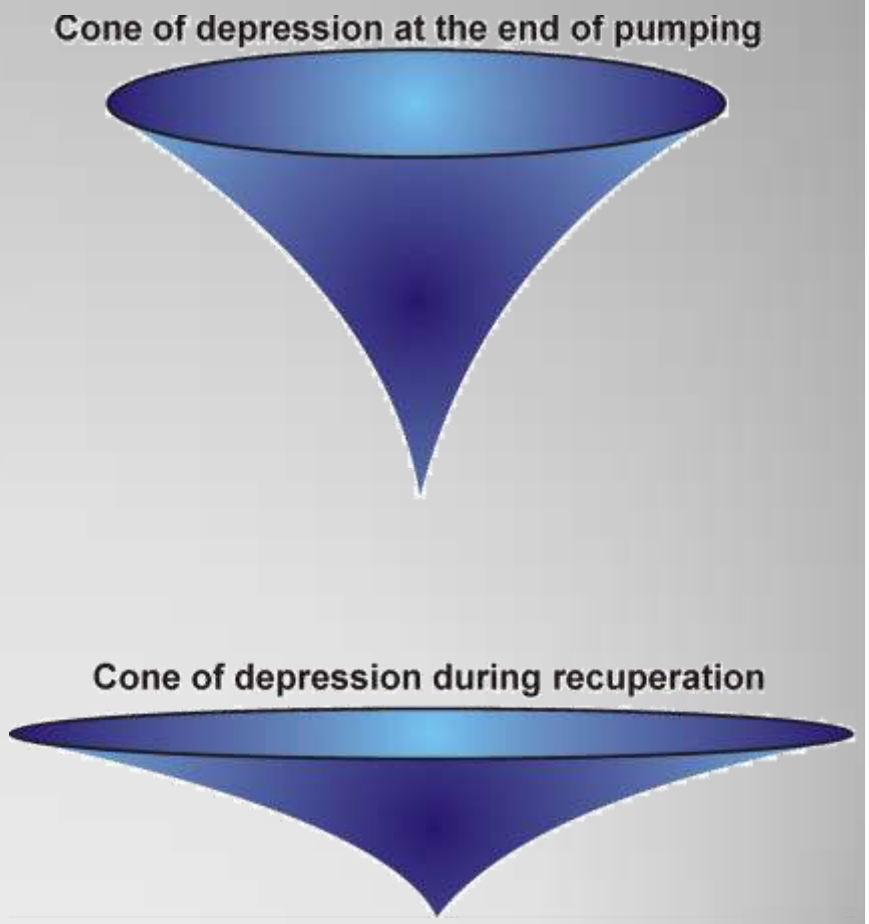
Recovery and the cone of depression

- During the process of recuperation or recovery, more and more desaturated portion of the aquifer gets resaturated
- This is indicated by a rise in water in areas away from pumping well also
- Due to rise in water level the hydraulic gradient towards pumping well becomes gentler with time, thereby reducing the rate of the aquifer contribution q
- Now, the water required for this resaturation process is derived by dewatering the peripheral areas of cone of depression *i.e. cone of depression continues to expand in peripherical areas even after the pump is switched off*
- Slowly, with time, the water level rises in the aquifer and finally get stabilized at a new static water level (which may be fractionally lower as compared to the original S.W.L.)



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Conducting pumping tests...some practical aspects

- The wells in the vicinity of chosen pumping wells should not be pumped at least 48 hours prior to a pumping test
- This ensures that water levels in the aquifer surrounding the pumping wells are as close to the static water level as possible and that there are no artificial hydraulic gradients
- The dimensions (depth and diameter / length & breadth) of the pumping well are measured
- Nature of the aquifer to be tested is ascertained on the basis of well inventory data:
  - rock type,
  - unconfined / confined / leaky
  - thickness of the aquifer

- A measuring point (MP) is selected and marked on the pumping well head and observation well head with respect to which all water levels are measured

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Pumping test data collection

- During pumping (drawdown part) the water levels are measured with respect to the MP at regular time intervals. The time interval could be
  - 1 min or 2min or 5min or 20 minutes and so on
  - The time interval is subjective and mostly dictated by hydrogeological field conditions
- In a well test, the drawdown is recorded in the pumping well only and in aquifer performance test drawdown is recorded in pumping well as well as in observation wells
- During the drawdown measurements the discharge of the pump (Q) is also measured (preferably with a simple drum/bucket of known volume using the stopwatch method)
- Pump discharge should be measured frequently as it tends to vary depending upon the efficiency of the pump, drawdown and voltage fluctuations
- Once the pumping from pumping well is stopped, the recovery or recuperation measurements are also made in pumping well as well as in observation wells at fixed intervals
- During the pumping test the water level in pumping well (if it is dug well) goes down exposing the walls of the well below water table for observation, regarding how and at what depth water is flowing into the well from the aquifer (i.e. information on the *inflow zones*)

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Thank you for your patience