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Lecture (2)

Vertical Distribution of Groundwater

The vertical distribution of groundwater mainly divided into two zones: zone of aeration and zone of saturation, as shown in Figure --.

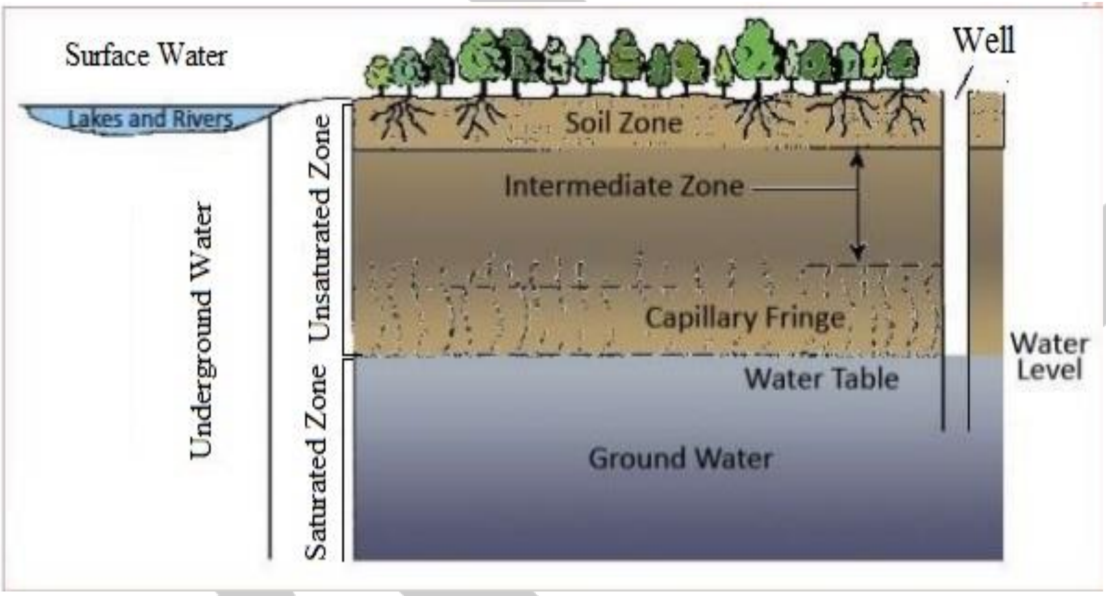


Figure --: A schematic cross-section showing the typical distribution of subsurface waters in a simple "unconfined" aquifer setting, highlighting the three common subdivisions of the unsaturated zone and the saturated zone below the water table.

Zone of aeration: The zone of aeration consists of interstices occupied partially by water and partially by air. The zone of aeration is subdivided into three types: 1. soil water zone 2. intermediate zone or vadose zone 3. capillary zone

► Soil water zone: Water in the soil-water zone exists at less than saturation except when excessive water reaches the ground surface as from rainfall or irrigation "its thickness varies with soil type".

The soil water zone was classified by 'Briggs' into three subzones depending on the concentration of moisture content they are 1. Hygroscopic water. 2. Capillary water. 3. Gravitational water.

1. *Hygroscopic water*: Absorbed from the which forms a thin layer of moisture on soil particles surface. The force is large so that this water is unavailable to plants.

2. *Capillary water*: Exists as continues films around the soil particles and it is yield by surface tension and is moved by capillary action and is available to plants.

3. *Gravitational water*: Is excess soil water which drains through the soil under the influence of gravity.

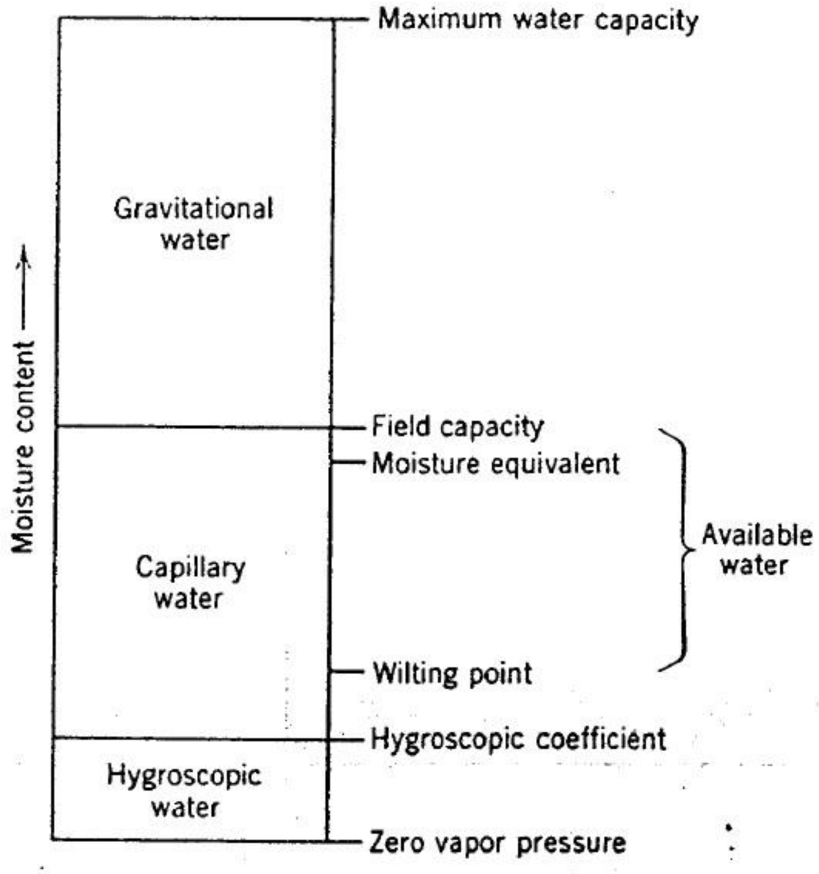


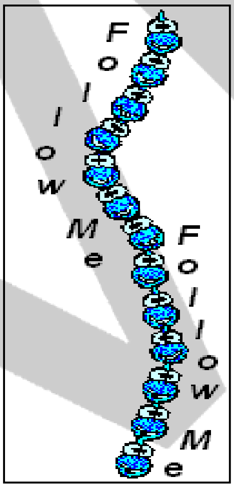
Fig. Soil water diagram showing classes and equilibrium points.

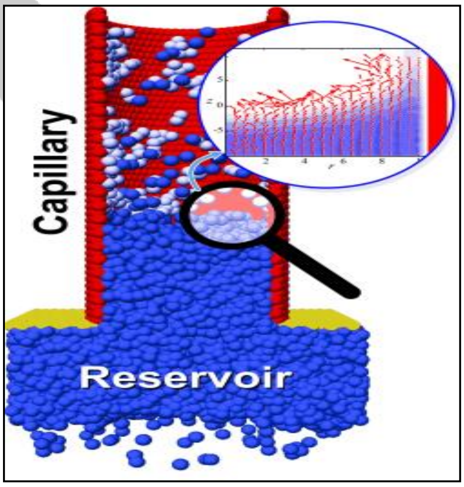
► The intermediate vadose zone: extends from the lower edge of the soil water zone to the upper limit of the capillary zone. The thickness may vary from zero, where the bounding zones merge with a high water table approaching ground surface to more than 100 m under deep water table conditions.

► The capillary zone: extends from the water table up to the limit of capillary rise of water or capillary fringe is one which lies immediately above the zone of saturation. The water available in the zone is termed as capillary water. Water is drawn up from the zone of saturation through capillary action and suspended by capillary force.

The thickness of this zone is dependent upon the texture of soil formation, above the zone of saturation. The capillary action increases when soil texture is fine, and decrease when the texture is coarse.

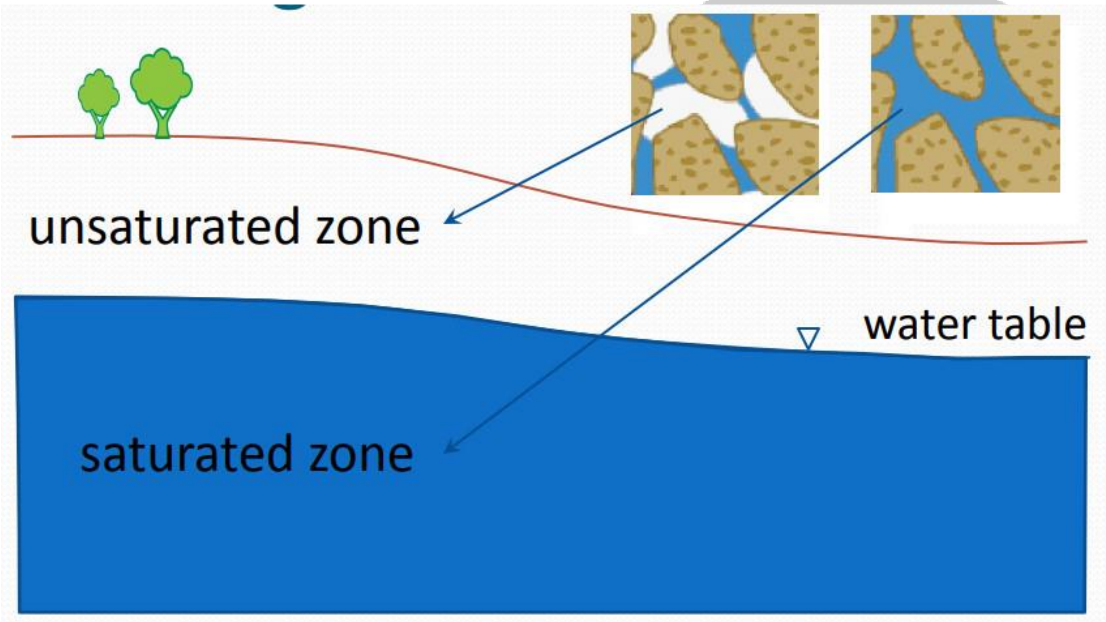
The important features of the capillary fringe are 1. Its lower part, which is immediately adjacent to the water table, contained water in all pores. 2. Moisture content is being equal to the porosity of soil formation. 3.Water pressure is less than the atmospheric pressure. 4. Thickness of the capillary fringe tends to get increased or decreased, depending upon water table fluctuation.





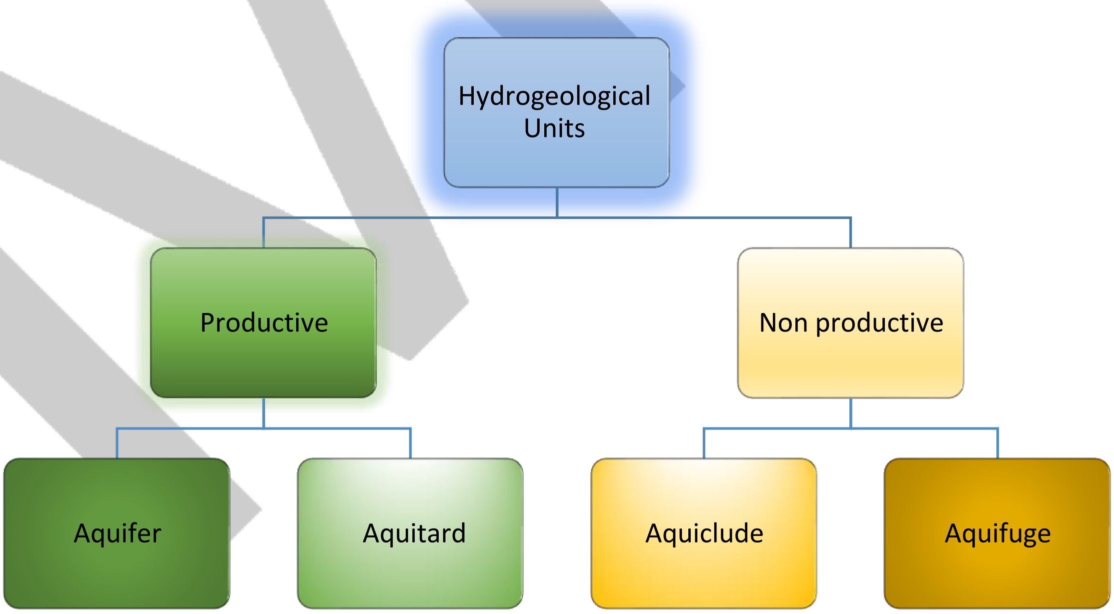
Water table: The uppermost surface of the zone of saturation is termed as the water table. The water table forms the boundary between the zone of aeration and the zone of saturation.

Zone of saturation: In the zone of saturation all interstices are filled with water under hydrostatic pressure. In the zone of saturation, groundwater fills all of the interstices; hence the porosity provides a direct measure of the water contained per unit volume.



Types of Geological Formations (Hydrogeological Units)

There are four types of geological formations (Aquifers, Aquitard, Aquiclude, and Aquifuge).



1. Aquifer

An aquifer is a ground-water reservoir composed of geologic units that are saturated with water (Store water), and sufficiently permeable to yield water in a usable quantity to wells and springs (Transmitted with easy).

Sand and gravel deposits, sandstone, limestone fractured are examples of geological units that form aquifers. Aquifers provide two important functions: (1) they transmit groundwater from areas of recharge to areas of discharge, and (2) they provide a storage medium for useable quantities of groundwater. The amount of water a material can hold depends upon its porosity. The size and degree of interconnection of those openings (permeability) determine the materials' ability to transmit fluid.

2. Aquitard

The reservoir is composed of geologic units that are store water relative productive.

An aquitard is a partly permeable geologic formation. It transmits water at such a slow rate that the yield is insufficient. Pumping by wells is not possible. For example, sand lenses in a clay formation will form an aquitard.

3. Aquiclude

An aquiclude is composed of rock or sediment that acts as a barrier to groundwater flow. Aquicludes are made up of low porosity and low permeability rock/sediment such as siltstone, shale, or clay. Aquicludes have normally good storage capacity but low transmitting capacity.

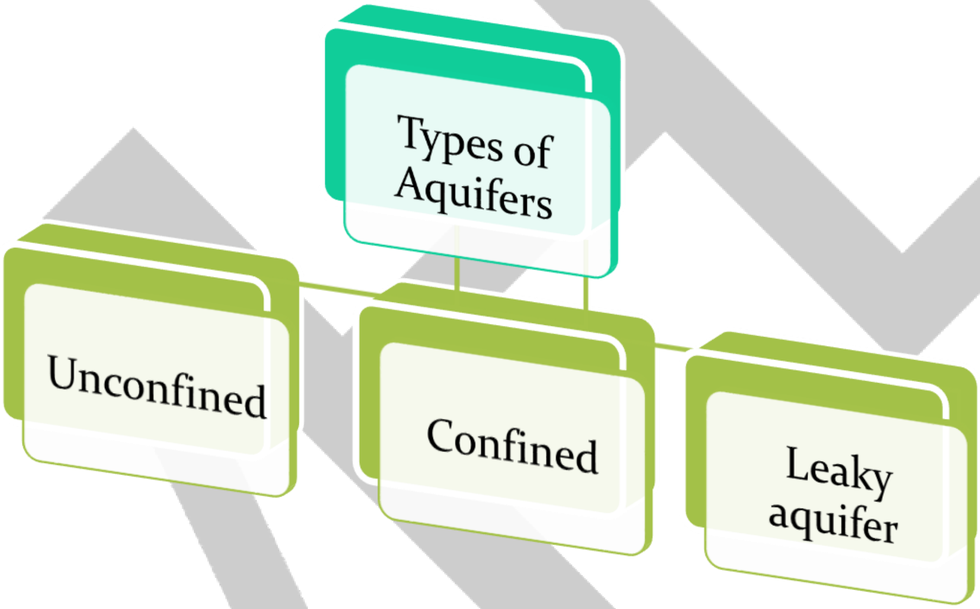
4. Aquifuge

An aquifuge is a geologic formation that doesn't have interconnected pores. It is neither porous nor permeable. Thus, it can neither store water nor transmit it. Examples of aquifuge are rocks like dolomite, basalt, granite, etc. without fissures.

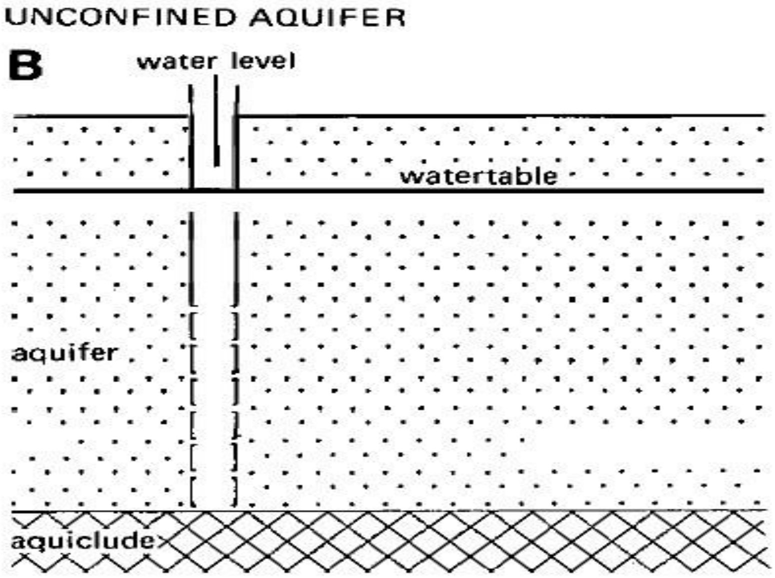
Types of Aquifers

Most aquifers are of large areal extent and may be visualized as underground storage reservoirs. Water enters a reservoir from natural or artificial recharge; it flows out under the action of gravity or is extracted by wells. Ordinarily, the annual volume of water removed or replaced represents only a small fraction of the total storage capacity.

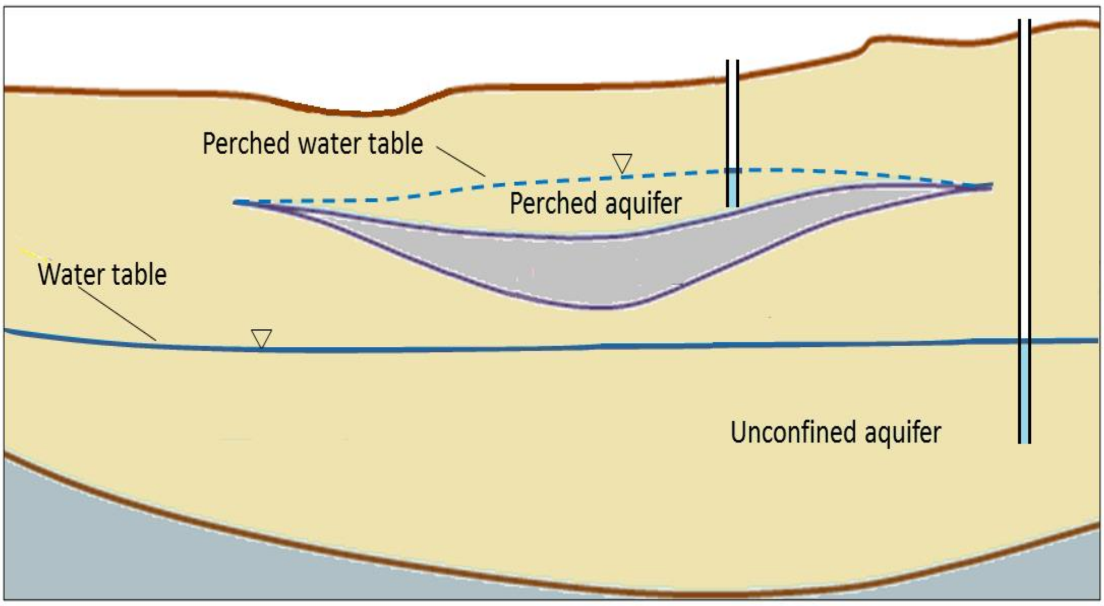
Aquifers may be classed as unconfined or confined, depending on the presence or absence of a water table, while a leaky aquifer represents a combination of the two types.



► ***Unconfined Aquifer***. An unconfined aquifer is one in which a water table varies in undulating form and slope, depending on areas of recharge and discharge, pumpage from wells, and permeability. Rises and falls in the water table correspond to changes in the volume of water in storage within an aquifer. Figure (-) is an idealized section through an unconfined aquifer.



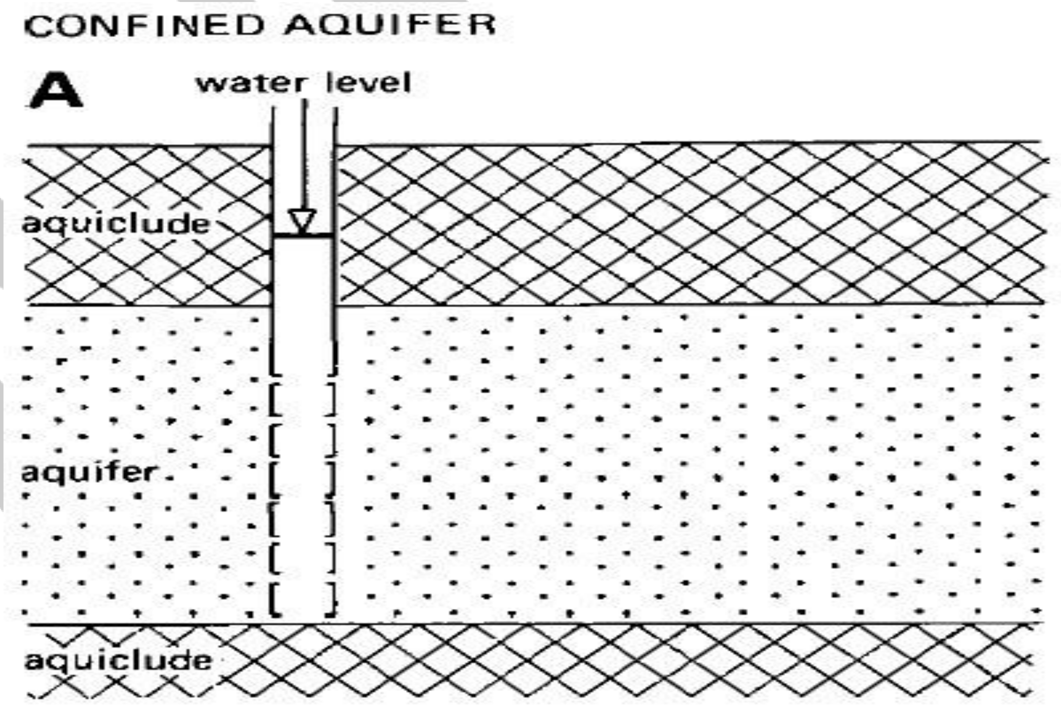
A special case of an unconfined aquifer involves ***perched water bodies***, as illustrated by Figure (--). This occurs wherever a groundwater body is separated from the main groundwater by a relatively impermeable stratum of small areal extent and by the zone of aeration above the main body of groundwater. Clay lenses in sedimentary deposits often have shallow perched water bodies overlying them. Wells tapping these sources yield only temporary or small quantities of water.



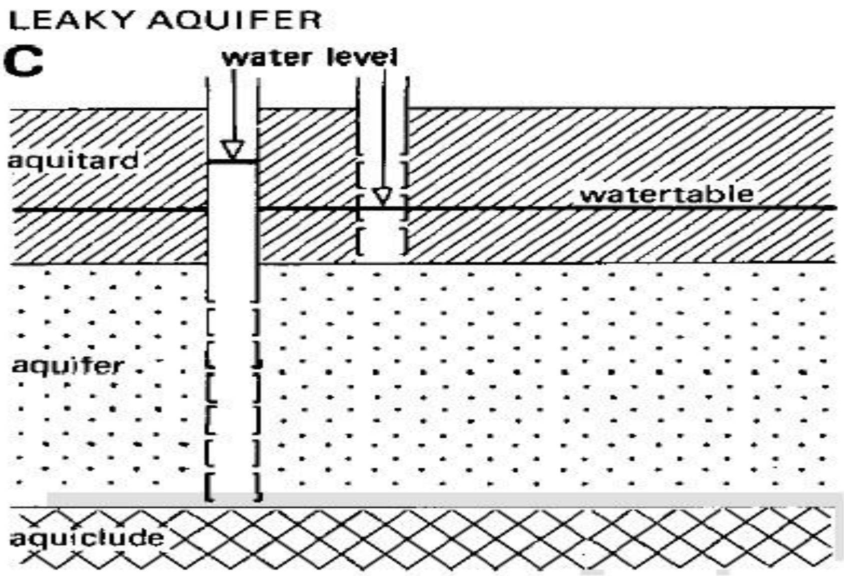
► ***Confined Aquifers***. Confined aquifers, also known as artesian or pressure aquifers, occur where groundwater is confined under pressure greater than atmospheric pressure by overlying relatively impermeable strata.

In a well penetrating such an aquifer, the water level will rise above the bottom of the confining bed. A region supplying water to a confined area is known as a recharge area; water may also enter by leakage through a confining bed. Rises and falls of water in wells penetrating confined aquifers result primarily from changes in pressure rather than changes in storage volumes.

It is necessary to have confined aquifers in different formation is the presence of a continuous source of recharge and presence two impermeable strata from above and below. Either the layer confined between two layers of upper and lower non-permeable and water-bearing pressure equal to atmospheric pressure, called the water layer connate.



► ***Leaky Aquifer***. Aquifers that are completely confined or unconfined occur less frequently than do leaky, or semi-confined, aquifers. These are a common feature in alluvial valleys, plains, or former lake basins where a permeable stratum is overlain or underlain by a semi-pervious aquitard or semi-confining layer. Pumping from a well in a leaky aquifer removes water in two ways: by horizontal flow within the aquifer and by vertical flow through the aquitard into the aquifer (see Figure --).



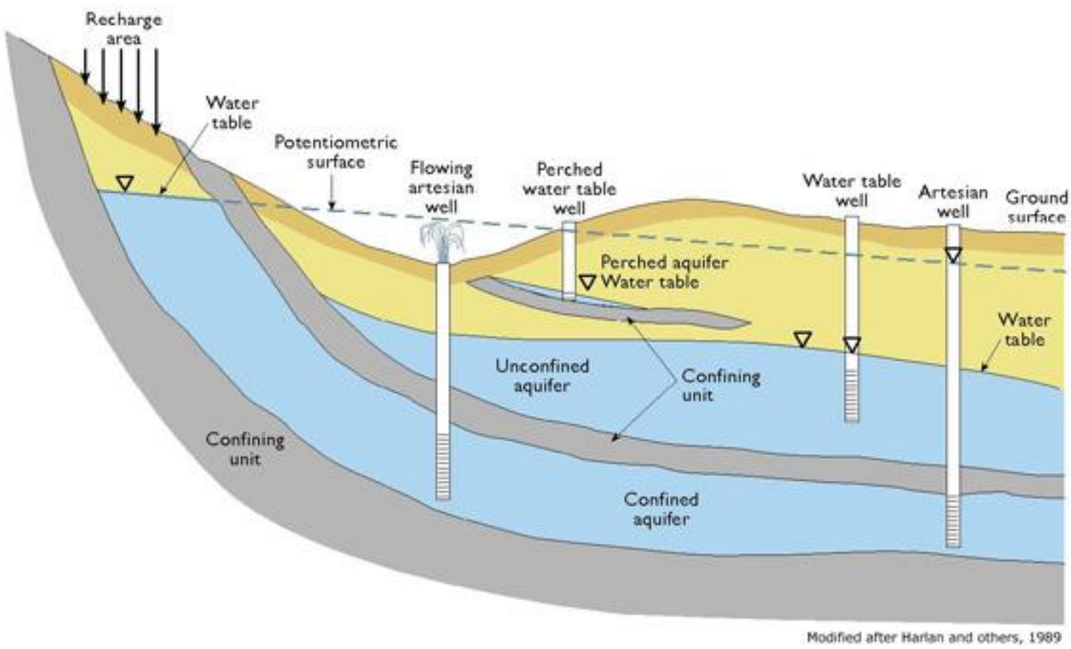


Figure --: Schematic cross-sections of aquifer types

References:

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