ABSTRACT

Groundwater is water located beneath the ground surface and underground water movement in soil and rocks. There are many method of obtaining hydraulic information from aquifers, but perhaps the most common and best is the pumping test or aquifer test. Without an estimate of the hydraulic properties of an aquifer, calculation of groundwater movement cannot be performed with any level of confidence. In other word, pumping test is the best method to obtain the hydraulic information. Objective of this study is to relate the relationship of the groundwater flow due to the pumping activities using 2 different conditions and determine the value of hydraulic conductivity (k) due to uniform size of sand. In more advance, the objective of this study to prove the Darcy's Law equation is relevant to applied in the study of groundwater flow. This study was carried out by using hydrology apparatus in the laboratory UMP with single and double mode pumping condition. The measurement of piezometer head showed the illustration of water table drawdown in the ground when using same size of sand which is 0.75 mm in the catchment area. There are 12 cases condition with 3 different initial groundwater levels which are 65 mm, 100 mm and 135 mm. This study was carried out in confined and unconfined aquifer Even though the flow rate, Q was set different value, hydraulic conductivity, k show that it still in the range of 0.01-10 mm. Data from the laboratory was compared with the value that stimulated from Darcy's Law equation. The value of differences were not much different and its can be proved that the equation is valid to apply in the hydrology field especially in groundwater pumping study. The result of this study highlighted the effect of pumping activities on water table: higher rate of pumping could cause the higher drawdown of water table especially at the well point. Then, if the pumping rate is too slow, a small cone of depression will result and the drawdown in observation well may be detected. Conversely, if pumping rate are too high, then the test will not run very long because the pumping level will reach the pump.

ABSTRAK

Air bawah tanah adalah air yang terletak di bawah permukaan tanah dan pergerakan air bawah tanah di dalam tanah dan batu. Terdapat banyak kaedah untuk mendapatkan maklumat hidraulik dari akuifer, tetapi yang terbaik ialah ujian pengepaman atau ujian akuifer. Tanpa anggaran sifat hidraulik akuifer, pengiraan pergerakan air bawah tanah tidak boleh dikaji. Dengan erti kata lain, mengepam ujian adalah kaedah terbaik untuk mendapatkan maklumat hidraulik. Objektif kajian ini adalah untuk mengaitkan hubungan aliran air bawah tanah yang disebabkan oleh aktiviti mengepam menggunakan 2 keadaan yang berbeza dan menentukan nilai kekonduksian hidraulik (k) kerana saiz seragam pasir. Objektif kajian ini membuktikan persamaan Hukum Darcy dengan kajian pengepaman air bawah tanah. Kajian ini dijalankan dengan menggunakan peralatan hidrologi di UMP makmal dengan keadaan mod mengepam satu dan dua. Ukuran ketinggian piezometer menunjukkan pengeluaran air di dalam tanah apabila menggunakan saiz pasir yang sama iaitu 0.75 mm di kawasan tadahan. Terdapat 12 kes keadaan dengan perbezaan tiga air bawah tanah aitu 65 mm, 100 mm dan 135 mm. Kajian ini telah dijalankan di akuifer terkurung dan tidak terkurung. Walaupun kadar aliran, Q tidak ditetapakan menetapkan nilai yang sama kekonduksian hidraulik, k menunjukakan bahawa ia masih dalam lingkungan 0.01-10 mm. Data dari makmal telah dibandingkan dengan nilai yang dirangsang daripada persamaan Hukum Darcy. Nilai perbezaan tidak banyak berbeza dapat membuktikan bahawa persamaan ini sesuai digunakan dalam kajian hidrologi. Hasil kajian ini menunjukkan kesan daripada aktiviti pengepaman terhadap paras air yang mana ketinggian kadar pengepaman akan menyebabkan ketinggian atau kejatuhan paras air terutama di perselihan perigi. Jika kadar pengepaman terlalu perlahan, kon kecil akan menyebabkan kejatuhan yang sedikit dan pengambilan ukuran agak lama. Sebaliknya, jika kadar pengepaman tinggi, maka ujian yang dijalankan tidak lama.

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v	Velocity
Q	Flow rate
D	Hydraulic depth
g	Gravity
p	Pressure
u	Viscosity of fluid
L	Length or diameter of the fluid
A	Cross-sectional area of flow
r	Radius
m^2	Meter Square
mm	Millimeter
m	Meter
m^3/s	Meter cubes per second
m/s	Meter per second
k	Hydraulic conductivity
π	pai
%	Percentage
b	Width
%	Percentage
H	Height
I	Intensity

LIST OF ABBREVIATIONS

USBR	United State Bureu of Reclamation

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Groundwater is an important part of the hydrological cycle and must be able to play a greater role in adding water utilities in the country. Groundwater is water located beneath the ground surface and underground water movement in soil and rocks usually crust (usually in aquifers). It can produce the quantity of water that can be used. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged and will flow to the surface naturally. The function of groundwater is also often used in the extraction well operating activities, agricultural, industrial and municipal.

Groundwater pumped more often in areas where the pumping total more than the natural flows. Typically such hydrology test, pumping will be done to achieve the target aquifer. Generally, the figure shows that the water table is an irregular surface that a gentler version of the overlaying ground surface. The water table also depend on the rising when rainfall adds more water to the ground and falling when drought reduces the water supply. When groundwater is pumped out of the ground the depth and shape of the water table can also change dramatically. In other word, quick pumps can drawdown the local water table right around a well and excessive pumping can also lower the water table over a wide region.

1.2 PROBLEM STATEMENT/MOTIVATION

The groundwater is the biggest reservoir of fresh, liquid water of earth. There also stored more water within the ground in all the lakes and rivers. In many parts of the world, agricultural, industrial, and domestic water demands can only be met by pumping water out of the ground. Pumping test can be undertaken to test the operation of the pumping and monitoring equipment, to make sure that everything safely and effiencienly. Typically, monitoring of groundwater level due to the water extraction or pumping in an aquifer is an importance as a fundamental for groundwater resources management. In order to study about this effect in groundwater aquifer, the hydrology apparatus was be used to analyse the drawdown of groundwater pumping.

1.3 OBJECTIVES

The objectives of this study are:

(i) To identify the drawdown effect due to pumping activities using 2 different conditions.

(ii) To determine the value of hydraulic conductivity (k) due to uniform size of sand.

(iii) To prove the Darcy's Law equation is relevant to apply in the study of the groundwater flow.

1.4 SCOPE OF STUDY

This study was focused on the drawdown effect due to pumping activities and the rainfall distribution. The experiment of this system was carried out in laboratory UMP

The scope of study includes of data collection for groundwater level and pumping rate using hydrology apparatus. Hydrology apparatus is the equipment to study the effect of rainfall distribution by using coarse sand.

1.5 IMPORTANT OF STUDY

The importance of this study is to observe the managing groundwater resources related to the quantity of groundwater due to pumping and effect of rainfall distribution pattern. This study is focused on groundwater that frequently used as a source of supply. In realise life, the water table is drawdown when pumping apply in well. The level of this drawdown depends on the quantity of water pumped out and ability of the surrounding aquifer to refill it. Thus, there is the limit to the quantity of water which may be drawn from a well, both from resources and economic aspects.

The apparatus of two well and a range of piezometer tapping in the base of the tank is equipped. The drawdown of either a single well or the interference of two wells may thereby be investigated. Water may be fed to the aquifer through the end of the tank rather than from the overhead sprinkles for these studies. Besides, it will be exposed to a significant role on drawdown patterns during this experiment. It also make more motivation about rising and falling off the groundwater level pumping and investigation flow from well.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this topic, this discussion will focus on the state of the groundwater hydrology model was used to assess the effect of pumping on groundwater sources. The study of groundwater is deal with the occurrences and movement in subsurface environment. It is the most complex of science which interconnect with hydrologist, geologist, agricultural engineers, geographer and probably others. Because of groundwater hydrology deal with the occurrences, movement and quality of water beneath the earth surface it is also important as the surface process. Figure 2.1 are shown the movement process of groundwater that practically applies in hydrologic cycle.

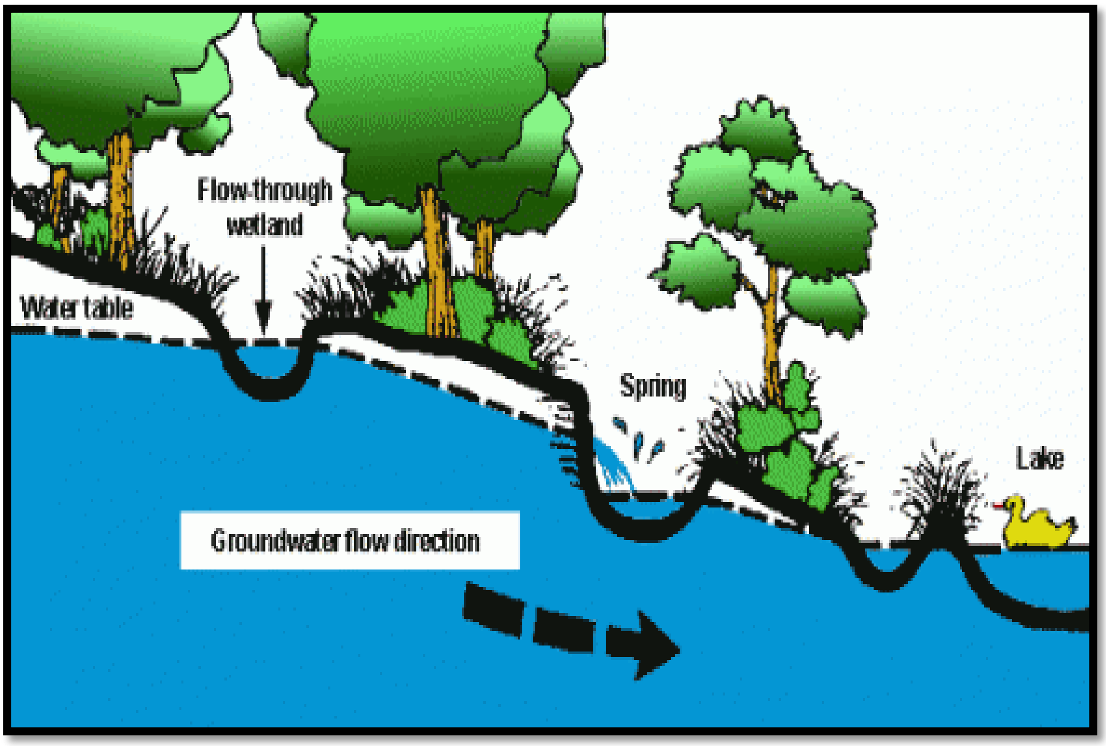

Figure 2.1: Groundwater movement

Source:http://wellwater.oregonstate.edu/groundwate-movement

2.2 HYDROLOGIC CYCLE

Hydrologic cycles are the continuous movement of water on above and below the surface of the Earth. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical process of evaporation, condensation, precipitation, infiltration, runoff and subsurface flow. According to the (Tarbuck and Lutgens, 1993) all agreed that part of the precipitated water runs on the ground surface in the form of surface runoff and this form streams, lakes, ponds etc, or it drain to the seas and oceans before it evaporates and joins the hydrologic cycle again. Another portion of the precipitation is consumed by vegetation and “under the influences of gravity continues moving downwards until it enters the groundwater reservoir” (Groundwater and Wells, 1966). This portion may or may not reach the groundwater table. In addition, some of the precipitation evaporates before it reaches the ground surface. Figure 2.2 show the hydrologic cycle process.

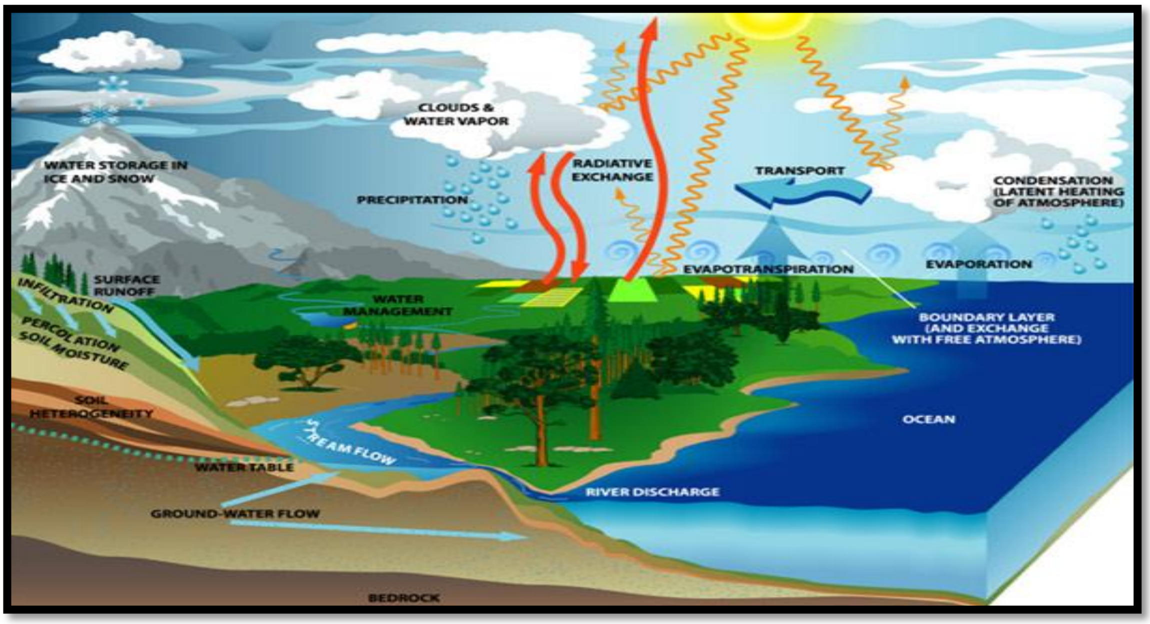

Figure 2.2: Hydrological Cycle

Source: http://oceanexplorer.noaa.gov

Current estimates are that the Earth's hydrosphere contains a huge amount of water about 1386 million cubic kilometres. However 97.5% of these amounts are salty waters and only 2.5% is fresh water. The greater portion of this fresh water (68%) is in the form of ice and permanent snow cover in the Antarctic, the Arctic and in the mountainous regions. Next, 29% exists as fresh groundwater. Only 0.3% of the total amounts of fresh water on the earth are concentrated in lakes, reservoir and river systems where they are most easily for our economic needs and absolutely vital for water ecosystems (Solley, 1998).

2.3 GROUNDWATER FLOW

Groundwater can be found almost everywhere. Figure 2.3 show the flow depends on how well the spaces are connected and the speed at which groundwater flows depend on size of the spaces in the soil. Groundwater in the saturated zone is always in motion and this flow takes places in a three dimensional space. When one or two flow direction appears dominant, quantitative analyses may be performed using one or two dimensional flow equations for the purposes of simplification. It is important to accurately analyze the entire flow field, which is often the case in contaminant fate (Kresic, 2007).

Groundwater is not confined to only a few channels or depression in the same way that the surface water is concentrated in stream and lakes. Rather it exists almost everywhere underground. It is found underground in these spaces between particles of rock and soil. Groundwater flow slowly through water bearing formation (aquifer) at different rates. Beside, recharge is the process in which water percolating through the soil replenishes groundwater, this is because the amount of precipitation and evaporation varies seasonally, the rate at which groundwater recharge will vary seasonally as well. In turn, the depth to the water table will vary (Lewis, 2003).

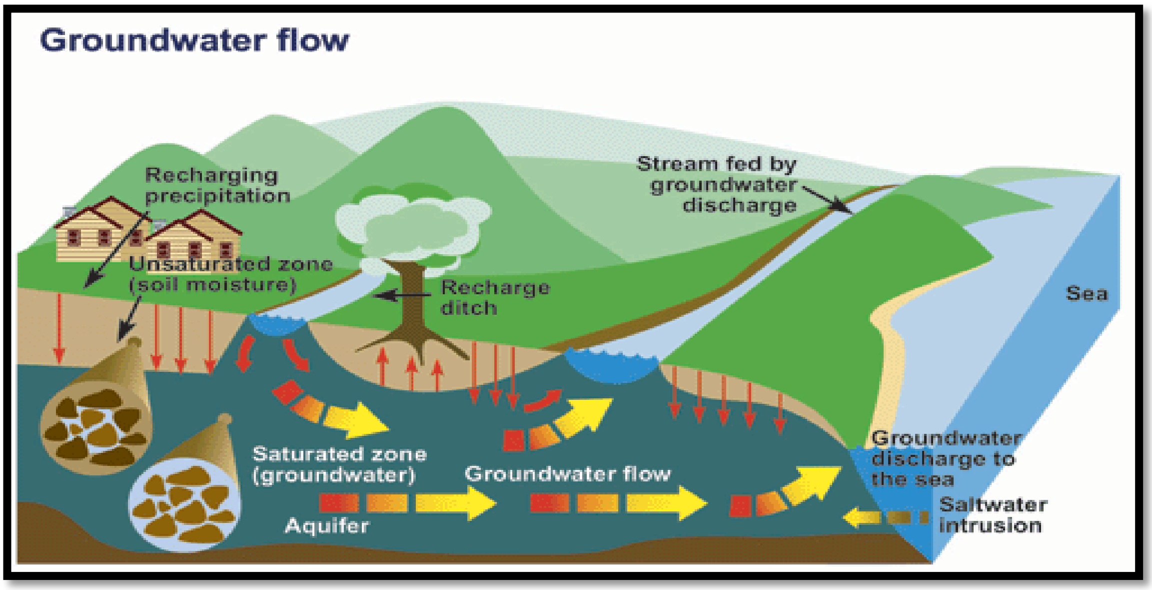

Figure 2.3: Groundwater flow

Source: http://oceanexplorer.noaa.gov

The water table is the upper boundary or top of the groundwater. Water moves within the saturated zone under the influence of gravity from areas where the water table is high toward areas where the water is lower. As it does, groundwater may flow into surface water such as lake or river. Infect in the process known as base flow, account for most of the water that recharges perennial stream, river and lakes. One common misperception, however, is that groundwater moves somewhat rapidly. In reality, groundwater moves much more slowly than water in a river or stream. This is because groundwater must overcome friction to move through the small spaces between soil particles and rocks (Lewis, 2003).

2.4 GROUNDWATER AND SUBSURFACE WATER

Most of rock and soil bear the earth's surface is composed of solid and voids. The voids are spaces between the grain of sand or cracks in dense rock. All water beneath the land surface occurs within such void spaces and is referred to as underground or subsurface water. According (Will, 2006) Subsurface water occurs in two different phase. One zoned, located immediately beneath the land surface in most areas, contain both water and air in the voids. This zone is referred to as the unsaturated phase. Other names for the unsaturated zone are zone of aeration and vadose zone as shown in Figure 2.4.

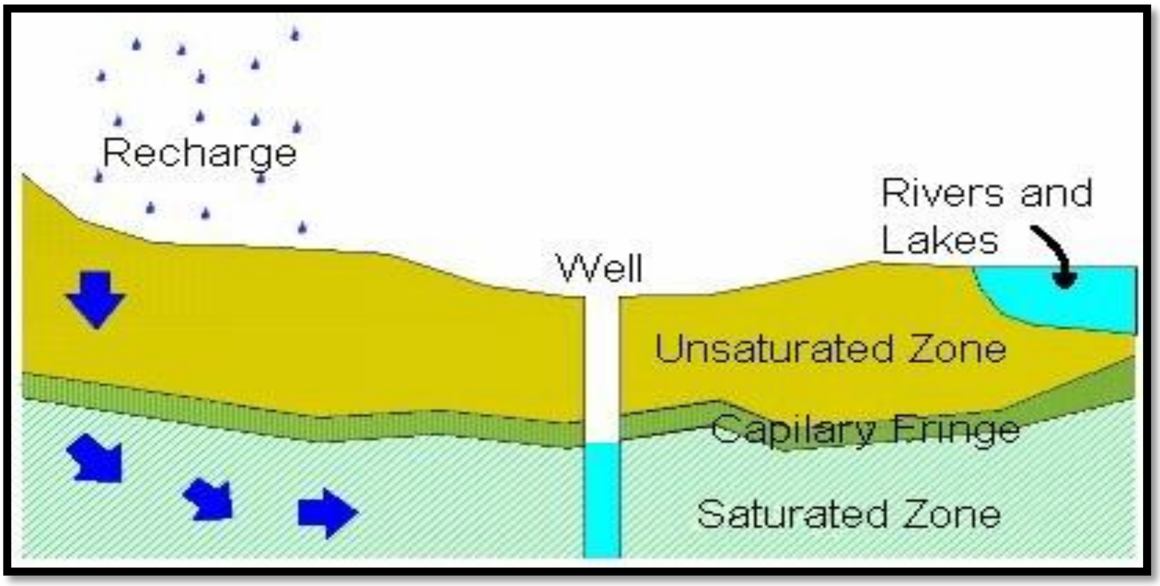

Figure 2.4: Zone of underground

Source: earthsci.org

The saturated zone is almost always underlain by a second zone in which all voids are full of water. This zone is defined as the saturated zones. Water in the saturated zone is referred to as ground water and is the only subsurface water available to supply well and springs. According (Lewis, 2003) groundwater distribution may generally be categorized into zones of aeration and saturation.

The saturated zone is one in which all voids are filled with water under hydrostatic pressure, in the zone aeration, the interstices are filled partly with air, partly with water. The saturated zone is commonly called the groundwater zone. The zone of aeration may ideally be subdivided into several subzones. Classifies these as follows:

(i) Soil water zone.

A soil water zone begins at the ground surface and extends downward through the major root band. Its total depth is variable and dependent on soil type and vegetation. The zone is unsaturated except during periods of heavy infiltration.

(ii) Intermediate zone.

This belt extends from the bottom of the soil-water zone to the top of the capillary border and may change from absence to several hundred feet in thickness.

(iii) Capillary zone.

A capillary zone extends from the water table to a height determined by the capillary rise that can be generated in the soil. The capillary band thickness is a function of soil texture and may fluctuate not only from region to region but also within a local area.

(iv) Saturated zone.

In the saturated zone, groundwater fills the pore spaces completely and porosity is therefore a direct measure of storage volume. Part of this water (specific retention) cannot be removed by pumping or drainage because of molecular and surface tension forces.

2.5 AQUIFERS AND CONFINING

Groundwater occurs in aquifer under two condition confined and unconfined. A confined aquifer is overlain by a confining bed such as an impermeable layer of clay or rock. An unconfined aquifer has no confining bed above it and is usually open to infiltration from the surface. Unconfined aquifers are often shallow and frequently overlie one or more confined aquifer. They are recharge through permeable soil and subsurface material above the aquifer. This is because they are usually the uppermost aquifer, unconfined aquifer are also called water table aquifer.

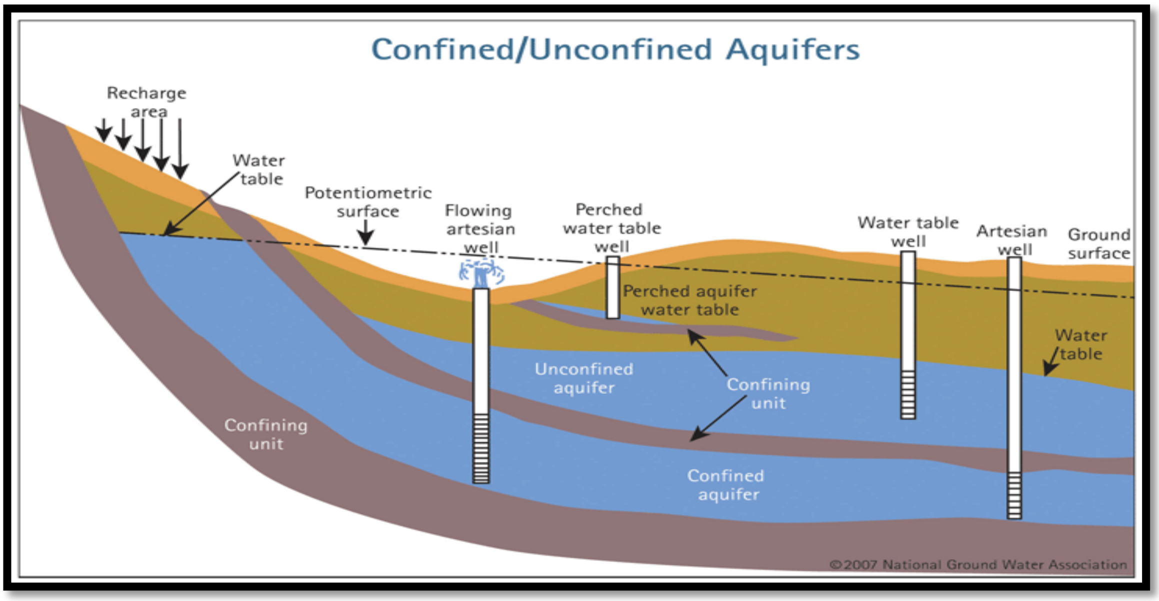

Figure 2.5: Confined and unconfined aquifer

Source: http://oceanexplorer.noaa.gov

Figure 2.5 illustrates major aquifer types in terms of the character and position of the hydraulic head (fluid pressure) in the aquifer. The top of saturated zone of an unconfined aquifer is called the water table. The hydraulic head at the water able equals the atmospheric pressure. The thickness of the saturated zone and therefore the position of the water table may change in time due to varying recharge, but the hydraulic head at the water table is always equal to the atmospheric pressure. There may be low permeable layer such as clay somewhere between the ground surface and the water table but as long as there is an unsaturated zone above the water table, the aquifer is unconfined (Barlow, 2003).

An impermeable or low permeable bed of limited extent above the main water table may cause accumulation of groundwater and formation of a relatively thin saturated zone called perched aquifer. Groundwater in aquifer may eventually flow over the edges of impermeable bed due to recharge from the land surface and continue to flow downward to the main water table, or it may discharge through a spring or seep if the confining bed intersects the land surface (Lohman, 1972).

A confined aquifer is bound above by a confining bed and its entire thickness is completely saturated with groundwater. The hydraulic head in the confined aquifer, also called peizometric level, is above this contact. The top of the confined aquifer is at the same time the bottom of the overlying confining bed. Groundwater in a confined aquifer is under pressure, such that static water level in a well screened only within the confined aquifer would stand at some distance above the top of the aquifer (Barlow, 2003).

A water table of unconfined aquifers, on the other hand is not an imaginary surface. It is the top of the aquifer and at same time, the top of the saturated zone below which all voids are completely filled with water. Hydrogeology structure is the term used to define discharge and recharge zones of groundwater system. Discharge and recharge are considered relative to both grounds surface and subsurface. Hydrogeology structure is the term used to define discharge and recharge zones of groundwater system. Discharge and recharge are considered relative to both grounds surface and subsurface. Figure 2.6 show the types of hydrogeology structure (Lohman, 1972).

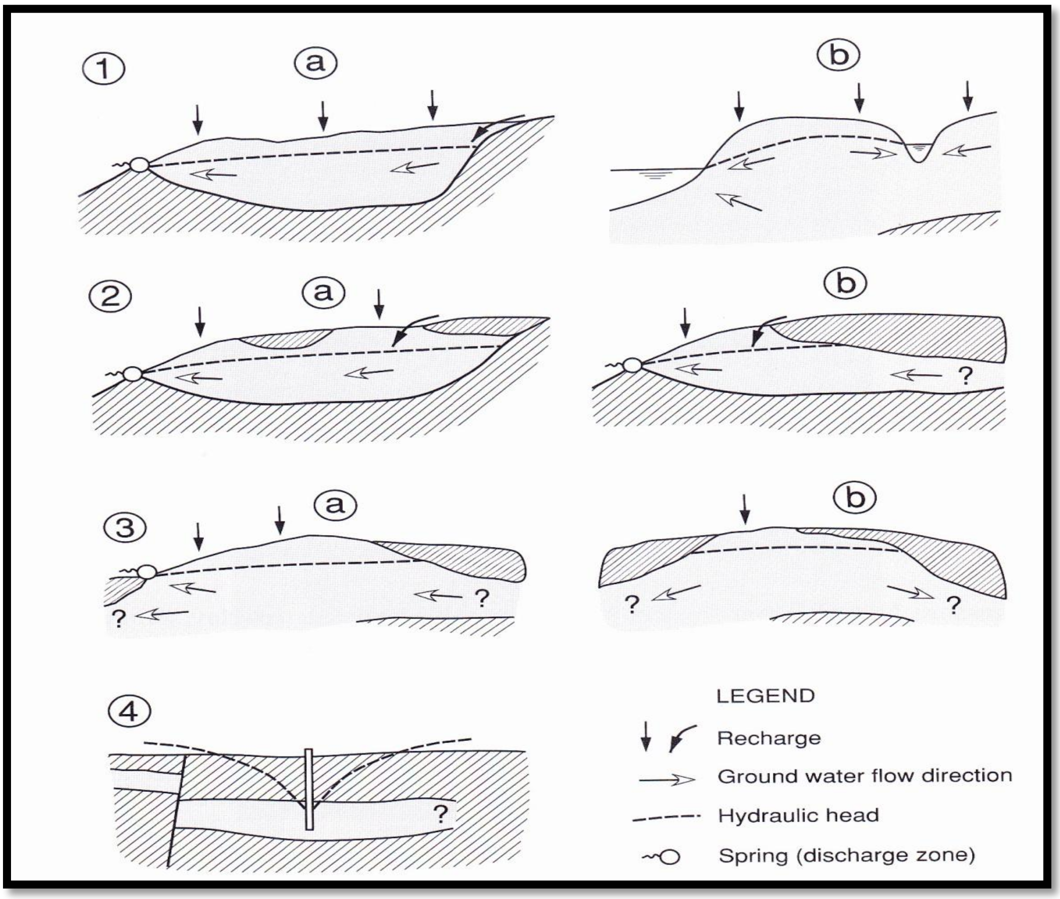

Figure 2.6: Types of hydrogeologic structure

Source: modified from USBR(1977)

(i) Figure 1 shows the open hydrogeologic structure. There will recharge and discharge zones are fully defined. Recharges take places over the entire areal extent of the aquifer, which directly exposed to the land surface. Discharge of the system is either at the contact with the impermeable base (case 1) or along a main erosion basis such as a large permanent river (case b).

(ii) Figure 2 show the semi open hydrogeologic structure. The discharge zones are fully defined and the groundwater system is partially isolated from the land surface by low permeable or impermeable cover. The recharge zones are mostly (cases 2 a b).

(iii) Figure number 3 is semi closed hydrogeology structure. Recharge zones are known or partially unknown, whereas discharge zones are only partially known case 3a and 3b.

(iv) Figure number 4 is closed hydrogeology structure. The groundwater aquifer is completely isolated by impermeable geologic unit and does not receive recharge. In practise, such an aquifer can only be discovered by drilling and the absence of any significant recharge is manifested by large, continuingly increasing drawdown during pumping.

2.6 GROUNDWATER MOVEMENT

Groundwater is generally always moving. Movement occurs from higher hydraulic head in recharge areas, where precipitation is generally higher to discharge areas of lower hydraulic head such as are well, river, lakes and wetlands. The reason groundwater move is because there always seem to be a “change in head” somewhere in groundwater system. Gravity is the force that moves groundwater that generally means it move downward. However, groundwater can also move upward if the pressure in a deeper aquifer is higher than that of the aquifer above it. This often occurs where pressurized confined aquifers occur beneath unconfined aquifers (Stanford, 2006).

A groundwater divide, like a surface water divide, indicates distinct ground water flow region within an aquifer. A divided is defined by a line on the either side of which groundwater moves in opposite direction. Groundwater divides often occur in highland areas and in some geologic environment coincide with surface water divides. There also strongly influenced by surface water flow. Where there are deep aquifers, surface and groundwater flow as may have little or no relationship. As groundwater flow downwards in an aquifer, its upper surface slopes in the direction of flow. This slope is known as the hydraulic gradient and is determined by measuring the water elevation in well tapping in aquifer. For unconfined aquifers, it is the slope of the water table (Ward,1990).