Chapter 2- What Is Groundwater?

Introduction

The continuous circulation of water between the oceans, atmosphere and land is known as the hydrological or water cycle (Fig. 2.1). Within this cycle the two main sources of fresh water supply available for use are surfacewater and groundwater. Surfacewater originates from rivers, lakes or streams, while water taken from beneath the land surface is known as groundwater.

Groundwater is often referred to as the hidden component of the hydrological cycle because unlike water in rivers, it can not be seen, except when it occasionally rises to the surface as springs. Because it cannot be seen, there has always been a certain mystery associated with groundwater. Unfortunately this factor also complicates its management.

Although groundwater may appear isolated, it is becoming increasingly apparent in Marlborough that it forms a continuum with rivers, springs and wetlands. In other words what happens in one part of the hydrological cycle will sooner or later affect another component.

What is an aquifer?

Groundwater is water that resides and travels beneath the ground surface. It occurs in a great variety of the rock formations and soil types that make up the earth's crust, but the most useful groundwater is associated with sedimentary rock types such as gravel or sand. Under the influence of gravity, water fills the pore-spaces between the grains of sands or gravels, and also in the fractures of solid rocks.

However not all saturated sediments can be considered to be an aquifer. Only when the underlying geology

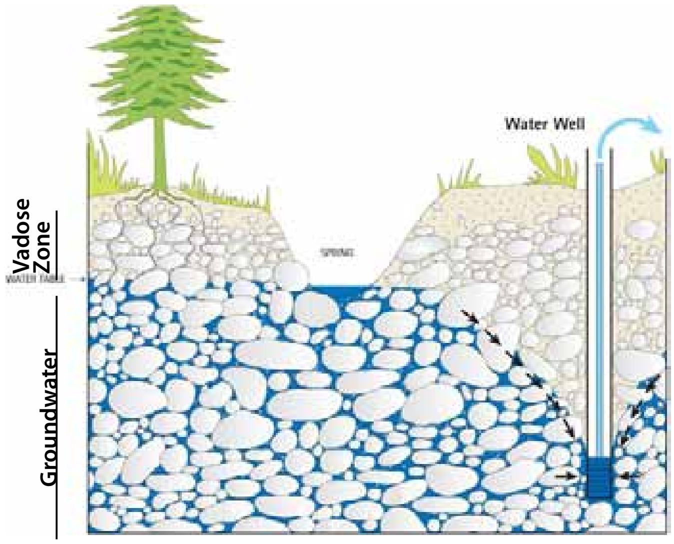

Figure 2.2: Groundwater above and below water table

contains sufficient quantities of groundwater, to provide a useful supply for an abstraction well, can it be called an aquifer. Rock type has the biggest influence on what constitutes an aquifer. In common with an oil field or mineral deposit, unless it is economically viable to extract the water from the underlying sediments it is not classified as an aquifer. Its status may change with time if water becomes more valuable and the extra work or energy required to extract it becomes justified.

A further distinction is made between water in the soil layer and groundwater in the saturated zone below the water table (Fig. 2.2). The unsaturated soil zone is also known as the vadose zone.

Rainfall percolating downwards from the surface moves through the overlying soil but doesn't become groundwater until it reaches the water table. Only then is it directly affected by pumping from the well.

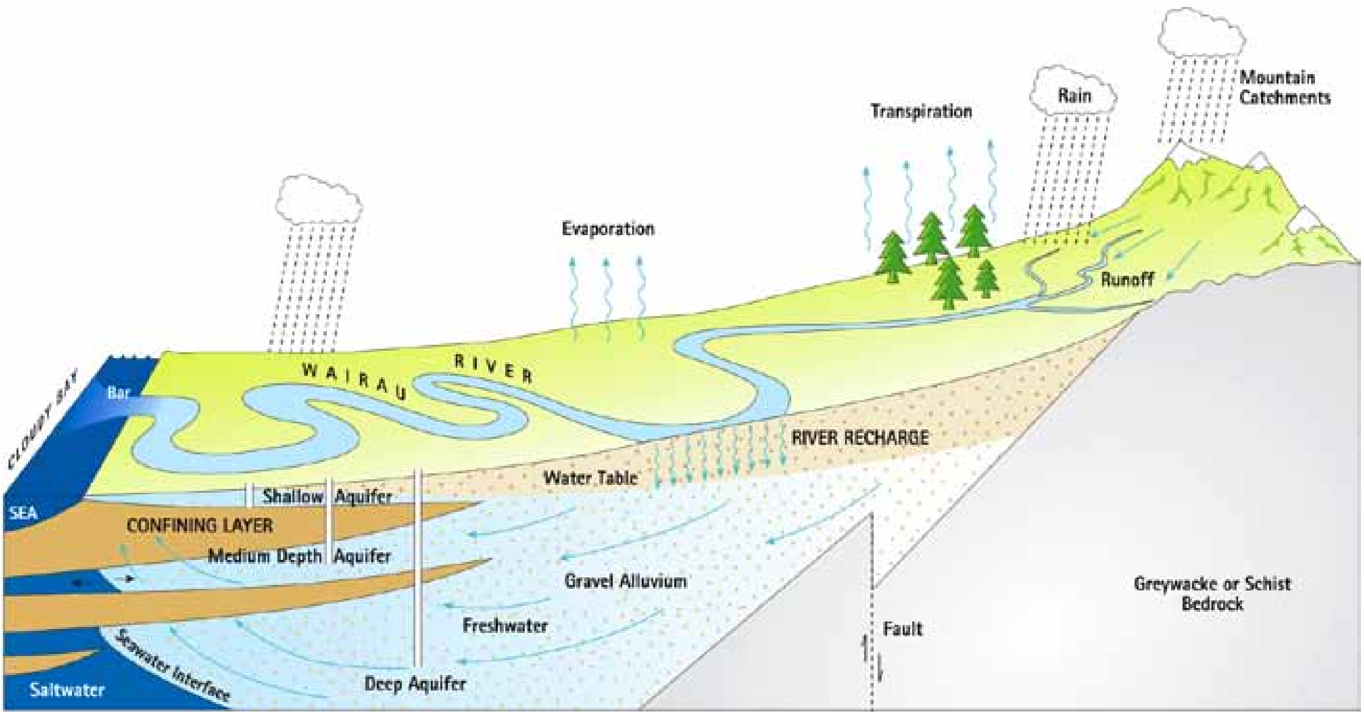

Figure 2.1: Wairau Plain hydrological cycle

Most people think of groundwater flow as being similar to an underground pipe or river, but this concept of a discrete flow is not the case at all. In reality, groundwater seeps slowly through natural gaps between the grains of a sedimentary gravels or fractures in hard rocks.

Aquifers perform two very important functions. Firstly they store water, which means rainfall that fell months or even years previously can be used when it is needed most, such as during a drought when rivers may be dry. This is similar to a bank savings account where money is put aside for a rainy day.

Secondly, aquifers convey water. This means water recharging the aquifer near Renwick for example, can flow underground and eventually end up many kilometres to the east near the Cloudy Bay coast. This is important for two reasons. Firstly it allows water removed from storage due to pumping or natural drainage to be replaced by new water. Secondly it provides water to areas where there may have been limited local rainfall.

Geology and groundwater

The physical nature of the earth determines its ability to store freshwater and its usefulness as an aquifer. The gaps between gravels that allow groundwater to flow through an aquifer are called pore spaces. The proportion of solids to pores is called the porosity. All rocks or sediments with some pore spaces provide storage for water.

Figure 2.4: Hillersden Formation on SH1

Each rock type or geological formation has a different porosity with the highest porosity being fine grained clays or sands. The more porous a geological formation is, the better the aquifer will be as it can store more water. However, aquifer performance is not only a function of how much water is stored within an aquifer, but also the degree to which these gaps are linked. This linkage allows water to flow through the aquifer so that it can move towards a well that is being pumped, and recharge water can infiltrate downwards from the surface to replace it. The degree to which water can move through a geological structure is known as permeability and is a measure of the degree of interconnectedness of a particular sediment type.

Only geological formations with the combination of relatively high porosity and permeability make worthwhile aquifers and are tapped by wells.

While clay is highly porous and stores lots of water, it is relatively impermeable. This means that the pore spaces in clay are not interconnected and flow is very slow. Clay deposits therefore make very poor aquifers and are known as aquitards.

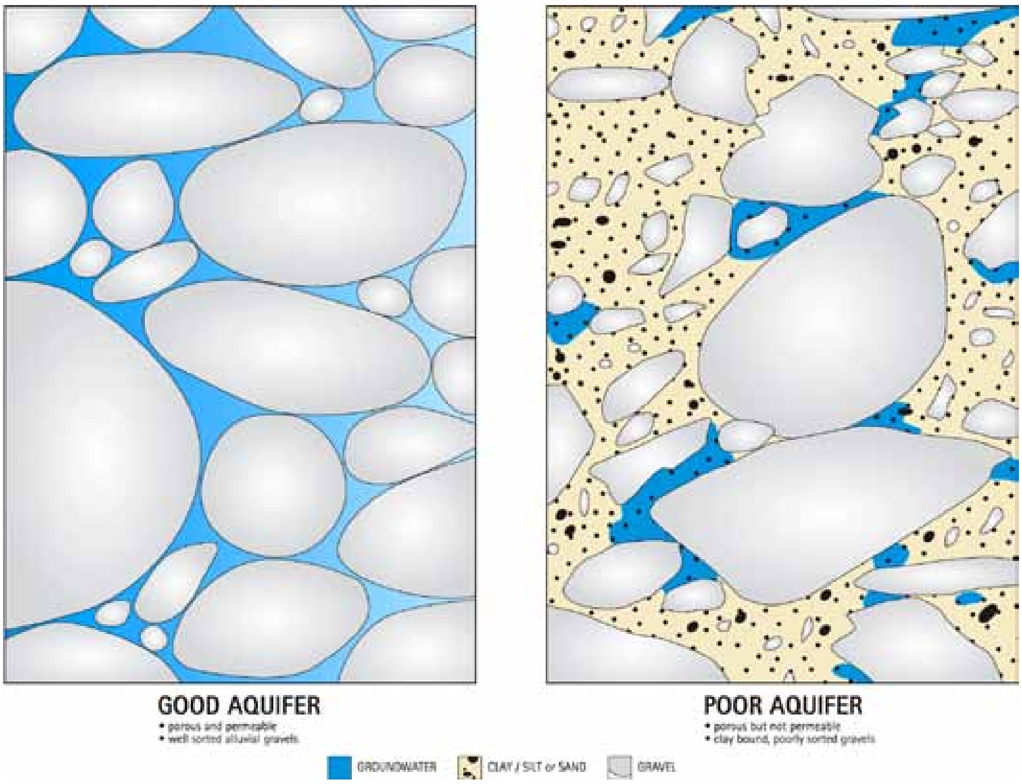

Figure 2.3: Aquifer geology

Figure 2.5: Clay bound gravels of the Hillersden Formation

The ideal material for hosting an aquifer is well sorted and rounded stones that have interconnected pore spaces with no clays or sands to restrict flow (Fig. 2.3). Well sorted and rounded stones are typical of the Wairau Aquifer beneath the Rapaura area. By contrast, poorly sorted gravels clogged with finer grained clays are typical of the Southern Valleys area of the Wairau Plain and represent poorer aquifers.

An example of a relatively impermeable gravel formation that has poor water storage can be seen in an outcropping at State Highway 1 (SH1) near the Riverlands railway overbridge (Fig. 2.4). This material belongs to the Hillersden Formation which forms the Wither Hills. The Hillersden Formation was originally deposited on land many thousands of years ago and is described as a poorly sorted and bedded clay-bound greywacke gravel, with sand and silt (GNS - 2000) (Fig. 2.5).

The last factor which determines the yield of an aquifer is the reliability and rate of recharge, particularly over summer when groundwater pumping is greatest. Groundwater systems located next to large perennially flowing rivers such as the Wairau River make the best aquifers because of the continuous source of replenishment from channel leakage.

Marlborough aquifers

Marlborough aquifers are small by world standards when compared to systems such as the Great Artesian Basin which underlies much of the eastern seaboard of Australia, but they are very significant for the local community who rely on the groundwater resources.

The most significant area within Marlborough for groundwater is the Wairau Plain. More wells have been drilled here than in any other part of the district. More work has been done investigating Wairau Plain groundwater resources, and more is known than elsewhere in the region.

Because of their hidden nature, public awareness of Marlborough's groundwater systems remains low. The profile of groundwater has however grown significantly over the past two decades.

All of Marlborough's economically important aquifers are associated with sedimentary deposits rather than the harder basement rocks. While groundwater is present within the fractured schist or greywacke rocks that form the mountain ranges, it can not be extracted in sufficient volumes to form a useful supply. The mountains do serve an important role by releasing water very slowly to the overlying alluvial aquifers that form the valley floors which in turn provide baseflow to local streams.

Marlborough's main aquifers are associated with the floodplains of larger rivers. Smaller rivers also have alluvium associated with them, but these sediments are not extensive enough to store sufficient water to form a significant natural reservoir. However flood plains only make up a small part of the land area of Marlborough

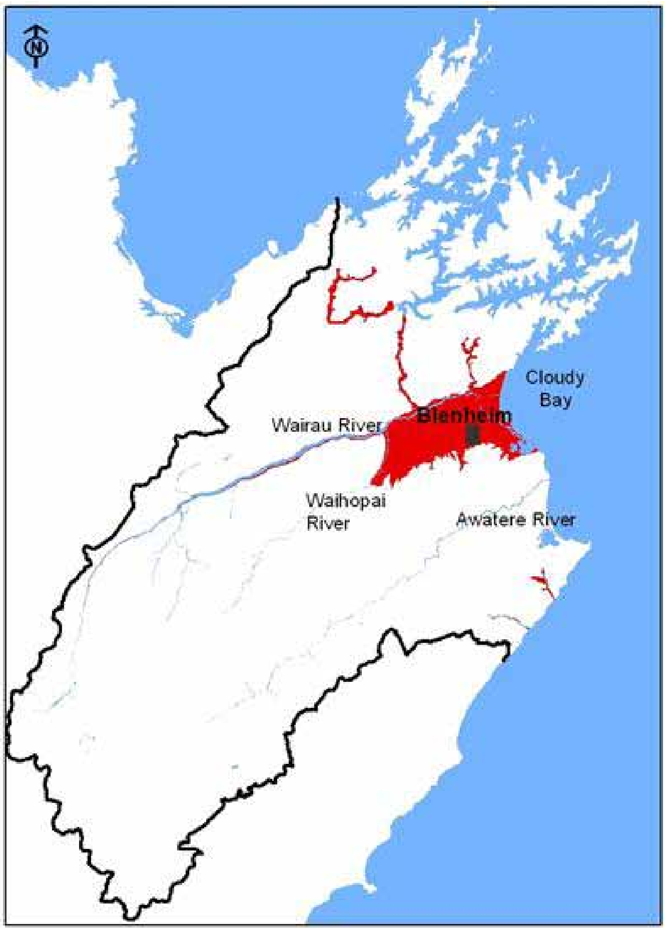

Figure 2.6: Marlborough aquifers 2010

(Fig. 2.6). The remainder consists of basement rocks such as schist or greywacke. It is unlikely that any significant new systems remain to be discovered as the upper layers of most alluvial deposits have been explored in detail. It is however possible that new deep aquifers may be discovered as the alluvial gravels forming the Wairau Plain are estimated to be around 500 metres thick, but to date most production wells only tap the upper 30 or so metres.

Not all sedimentary rocks act as ideal host material for aquifers. Much of the glacial material has been eroded from local mountain ranges near Lake Rotoiti, and is naturally clogged with fine clays or silts. This reduces its ability to store or transmit groundwater and while there certainly are aquifers within this material, they are low yielding and difficult to locate.

This low permeability glacial deposited material is geologically known as the Speargrass Formation. The Speargrass Formation has not been reworked to the same extent as gravels associated with the high energy Wairau River. This material accounts for a high proportion of the sediments underlying the Wairau Plain.

Gravels that may once have formed high yielding aquifers become less permeable as they are progressively buried over geological time. Compression due to the weight of the overlying sediments, together with chemical precipitates clog the pore spaces reducing the ability of the aquifer to store water.

Another material that acts as an ideal host formation for an aquifer are the coastal sands and fine gravels along the coast at Rarangi. However fine sand particles can cause problems for constructing and operating wells, especially when they are pumped at high rates.

References

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