Chapter 21: Deep Wairau Aquifer

Introduction

The Deep Wairau Aquifer (DWA) is the most recently defined of the Wairau Plain groundwater systems. It was discovered during the 1997/98 summer drought, following the failure of shallower wells when irrigators in the Fairhall area drilled a series of deep wells in the hope of locating a new source of groundwater.

The DWA is currently known to exist beneath the Fairhall, Woodbourne and parts of the Southern Valleys Aquifer areas, although future drilling may show it extends elsewhere (Fig. 21.1). The DWA exists at depths of greater than approximately 150 metres below the surface.

The depth of the DWA means that it is even more difficult to study than other Marlborough aquifer systems. As a result the dynamics of the DWA are the least understood of the local groundwater resources and all information about the DWA has come from well logs of the seven wells that are known to tap the aquifer.

DWA wells are significantly deeper than the majority of existing wells, most of which are less than 50 metres in depth (Fig. 21.2). They also have very long screened sections.

The DWA has a number of unique properties, one of which is its long residence time of groundwater. The age of the groundwater from the old Wairau Hospital well 980, has been determined to be 39,500 years old. This makes it the oldest dated water in New Zealand according to GNS Science isotope hydrologist, Dr Uwe Morgenstern.

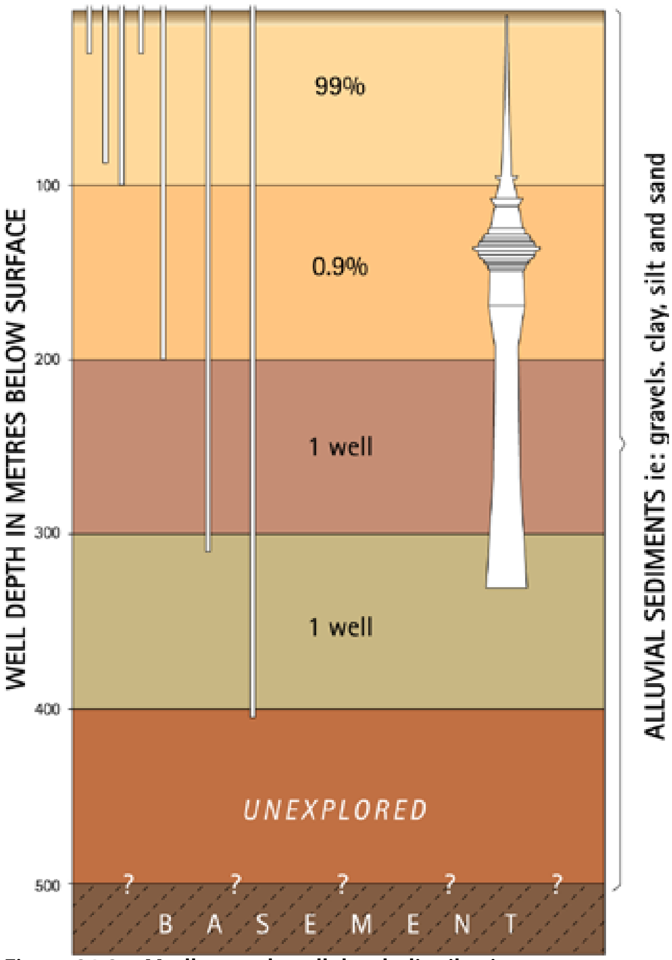

Figure 21.2: Marlborough well depth distribution

Groundwater systems

Drilling results suggest the DWA is not a single interconnected system like the Wairau Aquifer. It is more likely to consist of a series of semi-connected cells, with variable inputs and discontinuous flow between them (Fig. 21.3). However much remains to be discovered about the mechanics of the DWA.

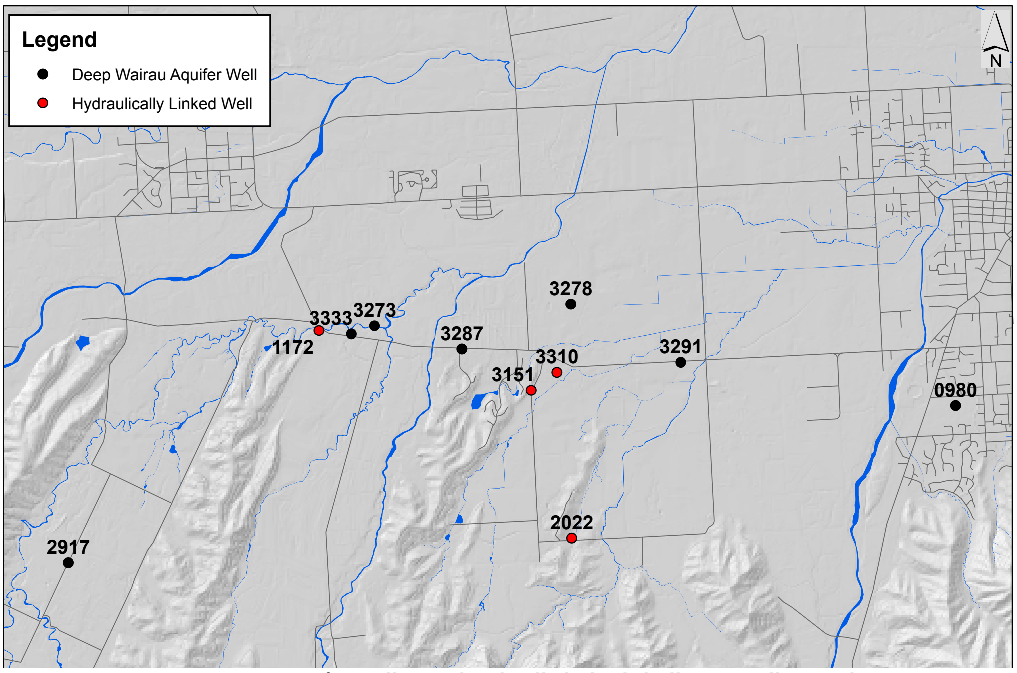

Figure 21.1: Deep Wairau Aquifer wells. Hydraulically linked shallower wells in red

A series of three aquifer tests were carried out in the late 1990s by Montana Wines Ltd and the MDC to quantify the effects of proposed pumping, and measure aquifer hydraulic properties. Testing demonstrated that the DWA was hydraulically linked to well 1172 in the neighbouring Brancott Aquifer, and wells 3151 and 3310 in the Benmorven Aquifer.

Because the aquifer is so large, this regional hydraulic connection was proven by implication,

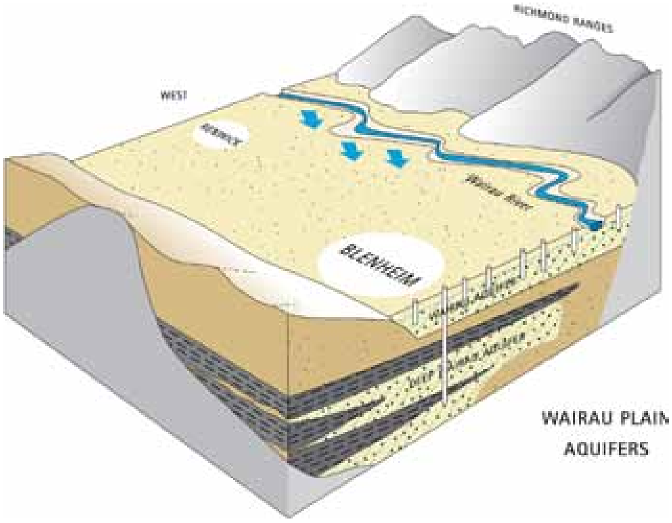

Figure 21.3: Conceptual model of Deep Wairau Aquifer

based on overlapping interference effects at mutually used observation wells. The only well not directly linked was the old Wairau Hospital well 0980, which is located too far east to respond to pumping.

A common characteristic of most wells tapping the DWA are artesian pressures. These pressures complicate testing procedures, as well as the day to day measurement of aquifer levels at the MDC permanent monitoring stations (Fig. 21.4).

Geologically the eastern wells such as 3291 and 3278 include a mix of terrestrially and marine derived sediments. Further west at well 3333, the DWA comprises exclusively of terrestrially derived material.

No clear geological boundaries have yet been defined for the DWA or how it is separated from the Southern Valleys aquifer systems.

Recharge and flow patterns

The DWA is relatively isolated from surface hydrological processes and this is reflected in their ancient groundwaters. Radioisotope measurements show groundwater sampled at various wells tapping the DWA were recharged from 9,100 years at well 3291 to 39,500 years before present at well 980. The average residence time was close to 20,000 years and implies groundwater flow rates are low, or the aquifer is blind with no recharge of younger water in recent times.

Little is known about its flow characteristics, or most importantly its source of recharge. DWA groundwater levels have remained relatively stable in response to pumping between 2001 and 2008, when an estimated 500,000 cubic metres of groundwater was drawn largely from well 3278. This implies the aquifer is larger than first thought, or active recharge is occurring.

In terms of its flow dynamics, an apparent evolution in groundwater chemistry can be seen from west to east. This suggests that the predominant flow is in an easterly direction. While this is the case at a regional scale, groundwater is moving so slowly that for all intents and purposes it is stationary compared to the velocities of shallower groundwater.

Significant vertical flows are also likely based on large differences in well pressure. For instance pressures at well 3291 vary from being nine metres above ground level, to three metres below the surface depending on depth.

The MDC have operated continuous water level recording instruments at four wells representing the DWA since the late 1990s. They observe the response to consented abstraction and seasonal cycles in aquifer behaviour. Records began earlier at the MDC exploratory well 2917 in December 1995, before the existence of a more extensive deep aquifer became apparent (Fig. 21.5). A similar pattern in long term aquifer levels at all sites supports the concept of a relatively interconnected series of aquifer pockets. The exception is well 0980 which exhibits a subdued response, with peaks or troughs which lag the other sites by months. This is consistent with it tapping the oldest water and representing the most isolated aquifer pocket.

Recovery of DWA levels following summer abstraction, and the similarity with shallower well behaviour suggests the DWA is not blind, but interacting with surface processes to some degree.

Figure 21.4: Measuring artesian pressure at Montana Wines Fairhall Estate deep well July 2010

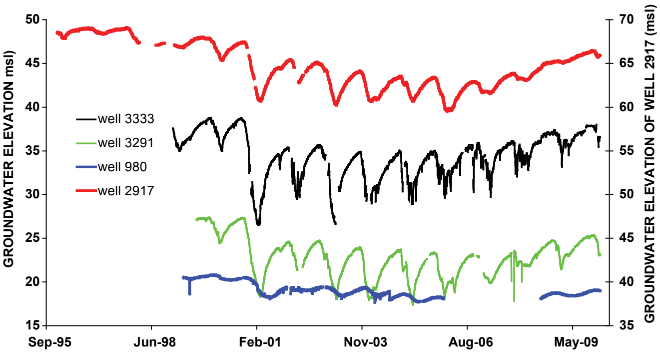

Figure 21.5: Groundwater time series

However the age of groundwater is getting older based on recent carbon isotope measurements (GNS - 2008) suggesting water is being drawn from older sources. Intuitively there should be measurable changes in both the age and chemical nature of DWA groundwater, unless the aquifer is very large relative to the volume of water that has been abstracted until now.

Hydraulic properties

Measured aquifer transmissivity values vary from less than 10 m^2/day to around 650 m^2/day. Storativity values range from 10^{-3} to 10^{-5}. This variability is consistent with a heterogeneous aquifer structure. Aquifer storage is low and generally indicates a confined structure.

Aquifer yields generally decline with pumping duration, indicating channel type water bearing layers. Yields are also higher in wells located further north, due to the presence of thicker or more permeable gravels further out onto the Wairau Plain, and better sorting of gravel fan deposits.

Groundwater chemistry

The DWA is deeply buried and isolated from the atmosphere and as a result, unique chemical conditions develop within the aquifer. There is virtually no oxygen which has led to reducing chemical conditions and as a consequence the groundwater is highly mineralised and generally of poor quality (Fig. 21.5).

Geochemically the water is significantly different to shallower groundwaters, with higher percentages of sodium or chloride, and lower fractions of sulphate or calcium.

There are also distinct chemical differences between the groundwater sampled from the four deep wells. Water from wells 3291 and 3333 is the least evolved with significant proportions of calcium or sulphate. Water from wells 0980 and 3278 is dominated by sodium, chloride and bicarbonate. This shows the influence of reduction reactions and minerals linked to the marine confining layers.

These differences in chemistry indicate a heterogeneous aquifer structure. This is further explained by sluggish flow and a lack of blending meaning groundwater is evolving slightly differently depending on the geology and chemical conditions that exist in a particular part of the DWA.

A consequence of bringing old, highly evolved groundwater from the DWA into contact with the atmosphere at the surface for the first time in several thousands of years, is corrosion of metal plumbing or fittings, and a distinctive odour of hydrogen sulphide gas.

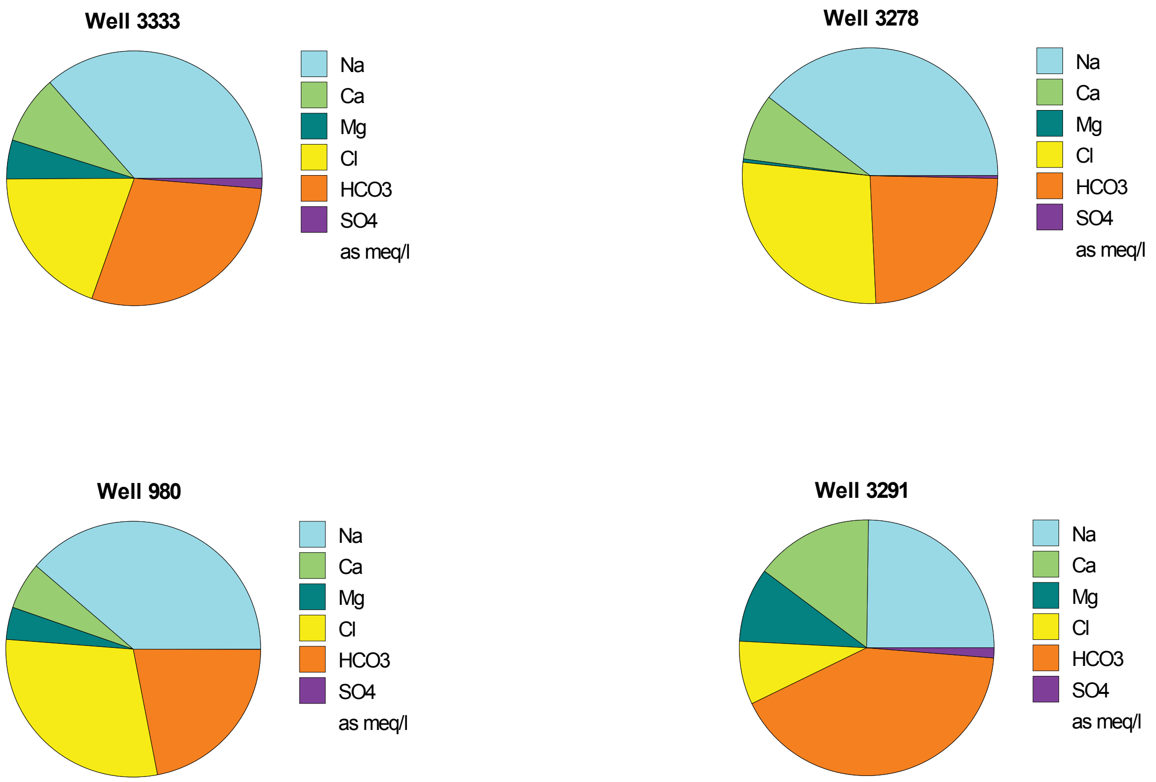

Figure 21.5: Groundwater composition

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