# Chapter 28: Benmorven Aquifer

## Introduction

The Benmorven Aquifer is located to the south-west of Blenheim and it is the most easterly of the three Southern Valleys aquifer systems as it underlies the loop road formed by Paynters, Benmorven and New Renwick Roads (Fig. 28.1).

Little was known about groundwater resources in this area until the early 1970s when landowners began to drill wells in search of water. The majority of the landowners were successful, although not necessarily with the first well they drilled. These early wells were drilled primarily for stock and domestic water supply purposes. Since that time, experience provided by the drilling of many wells has demonstrated a predictable source of groundwater.

Benmorven has a higher proportion of community water schemes compared to the other deeper Southern Valleys aquifer systems. These schemes supply rural residential subdivisions whereas elsewhere in the Southern Valleys, most water is used for vineyard irrigation.

Wells in the Benmorven area are relatively deep by Wairau Plain standards with the majority being screened at 30 metres or more below the surface. This reflects the existence of a natural confining layer which must be penetrated to source groundwater.

The area has several unique physical characteristics which distinguish it from the neighbouring Omaka or Brancott Aquifers. The primary difference lies in the geology of the formations which host the aquifer and the way in which it is recharged as it is closer to the coast and has been partly formed of marine sediments. The other two Southern Valley systems are further from the sea and consist entirely of terrestrially derived material. The other distinguishing feature of this valley is the lack of a riparian type aquifer due to the absence of a large river.

## Groundwater systems

The Benmorven Aquifer has one of the most highly confined structures of any groundwater system in Marlborough with the capping layer of the aquifer being formed of thick beds of fine grained marine clays. These are thought to be the Winterholme Formation at the surface, or the Parikawa Formation at greater depths. These clays were deposited by the sea when it repeatedly invaded the south and eastern portions of the Wairau Plain during the Pleistocene geological period.

While shallow groundwater does exist, most wells tap the deeper Benmorven Aquifer. The deepest wells drilled to date are wells 3375 to a depth of 156 metres, and wells 3377 and 3177.

The boundaries of the Benmorven Aquifer are formed by greywacke bedrock shown in grey, and relatively impermeable cemented gravels forming the ridgelines, although these do contain some groundwater (Fig. 28.2).

Most groundwater is found in the younger clay-bound sediments filling the valley floor between these formations and trapped beneath the clay confining layer. However the Benmorven Aquifer isn't a single interconnected groundwater system. It appears to consist of at least three localised pockets of groundwater (Fig. 28.3).

The existence of these pockets was first demonstrated by testing as far back as 1985, when some wells but not others responded to pumping. These initial tests identified pockets B and C in the south-eastern corner of Benmorven.

A further series of tests were conducted by the MCRWB and MDC staff between 1988 and 1994 to refine understanding of the extent of these aquifer pockets.

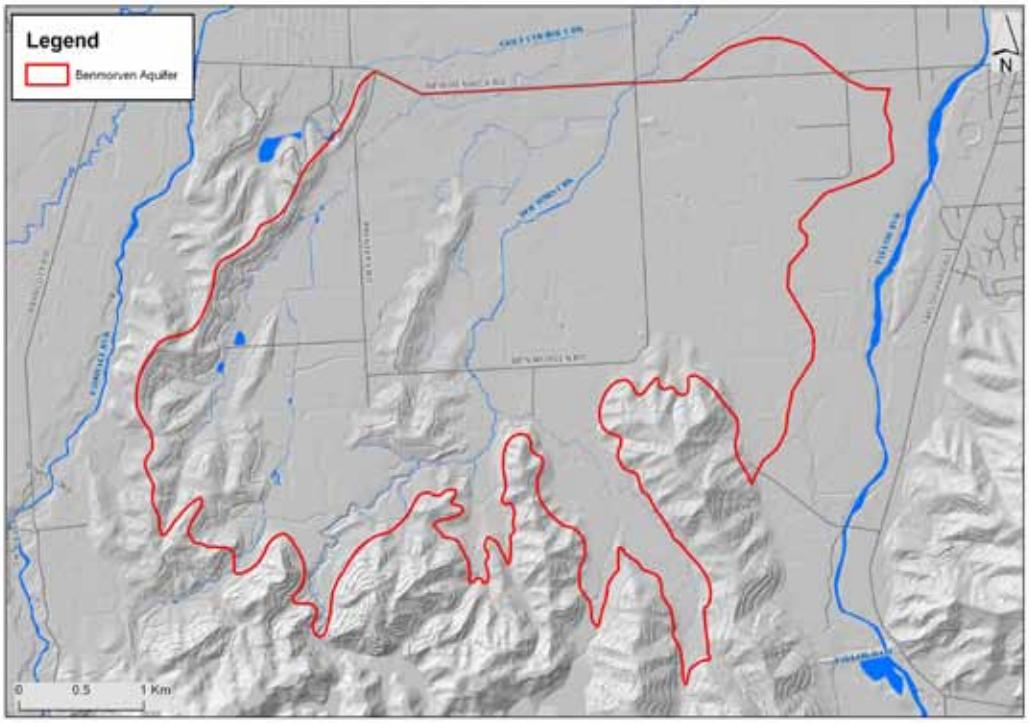


**Figure 28.1: Benmorven Aquifer boundary**

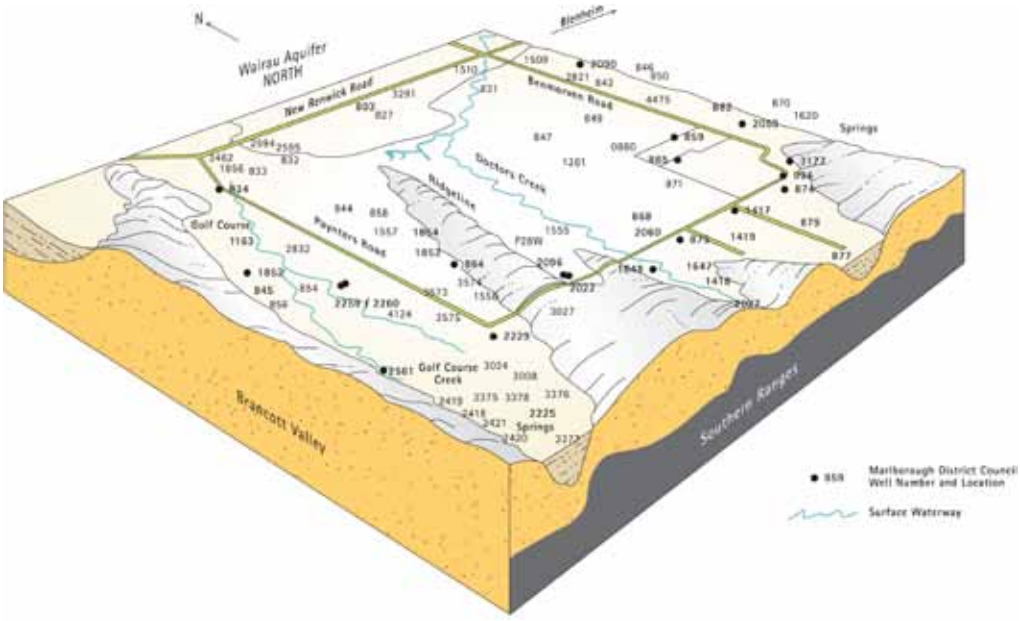


Figure 28.2: Benmorven well locations, formations and topography

It is thought that recharge occurs along the southern margins of the Benmorven Aquifer where the alluvium meets the hills and forms an entry point for catchment runoff. The higher elevations at this point mean there is likely to be a downwards flow gradient into the aquifer. The extensive and impermeable nature of the confining layer further south, in conjunction with artesian pressures, means there is little likelihood of direct rainfall recharge in the lower lying areas.

The presence of these barrier boundaries also shows up in aquifer test results (Fig. 28.4). If the aquifer were extensive, the slope of the drawdown would be constant. However, in this test it steepens over time, indicating the cone of depression generated by pumping the well has encountered less permeable boundaries. The drawdown curve indicates that there are multiple boundaries which define the edge of aquifer pocket B.

The initial slope translates to an aquifer transmissivity value of 118 $m^2$/day. At about 500 minutes the slope steepens, and aquifer transmissivity halves to 57 $m^2$/day. The test results indicate an aquifer storativity of $1x10^{-4}$, which is consistent with the confined aquifer structure.

The Benmorven Aquifer is not horizontally homogeneous and it is likely to be vertically stratified as well.

## Recharge and flow patterns

The thick layers of marine clays present at Benmorven act as a natural lid on the aquifer, slowing the recharge process. This means that the same rainfall event at Benmorven isn't as effective in replenishing groundwater as for the nearby Omaka or Brancott Aquifers with less confined structures.

The sluggish recovery of aquifer levels since the 2000/2001 drought demonstrates the naturally slow recharge rate of the Benmorven Aquifer. Prior to the 1997/98 drought, pressures in the Benmorven Aquifer were artesian by up to five metres (Fig. 28.5).

Artesian pressures were the norm for deeper Benmorven Aquifer wells drilled prior to 1995. However, levels have fallen over time due to a combination of increasing water demand and drought during the late 1990s (Fig. 28.6). The 15 metre drop in water level at well 2022 is the largest observed fall for any aquifer in the district. This reflects the fact that from 1980 onwards the Benmorven Aquifer has been used more intensively as a source for irrigation water, winery production and increasingly for community rural residential or individual domestic supply.

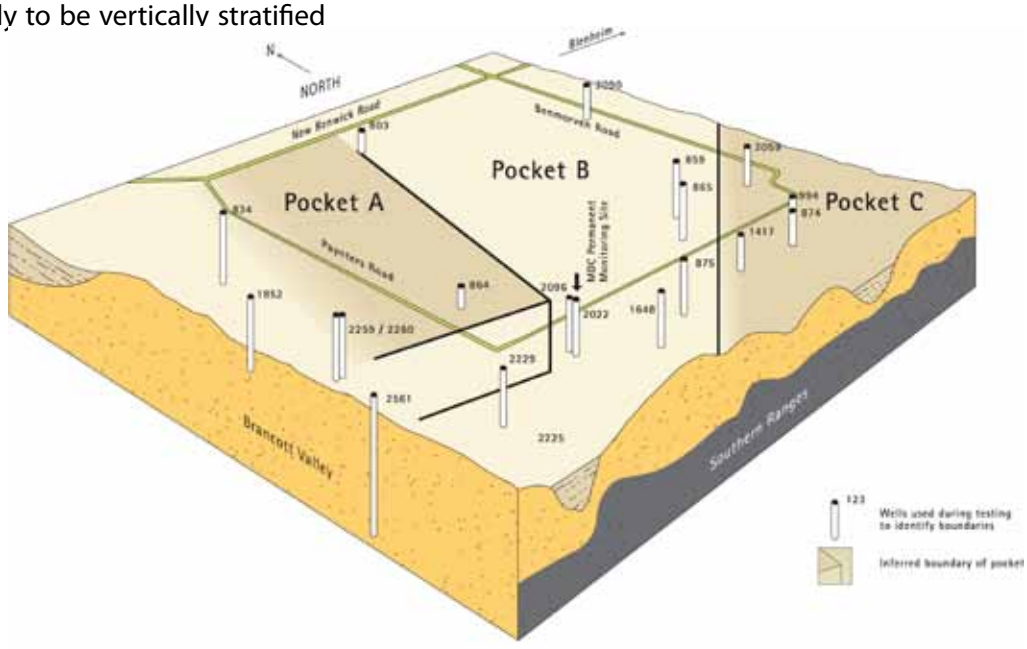


Figure 28.3: Benmorven Aquifer pockets

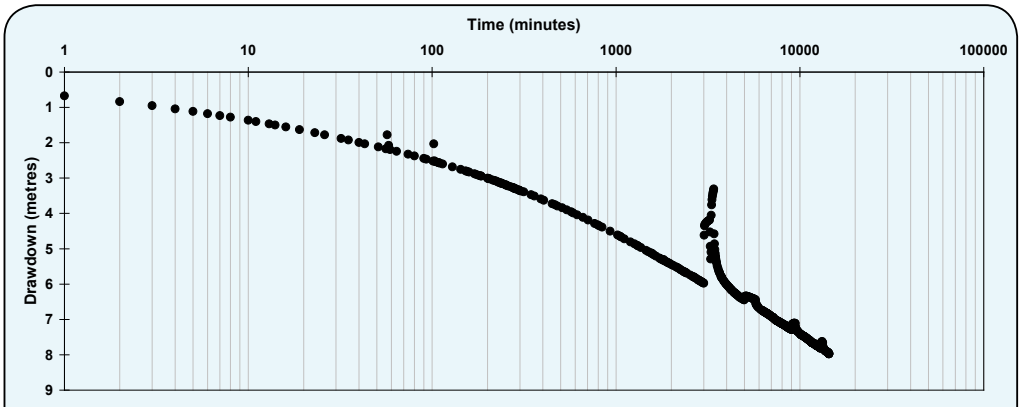


**Figure 28.4: 1990 aquifer test. The rise in level at between three and four thousand minutes represents a power failure which caused the pump to stop and levels to recover for a short period.**

In late 2000 MDC staff surveyed well levels across the Benmorven area to map the direction of groundwater flow. This was a difficult exercise given the artesian pressures present at the time. In order to measure the artesian water levels at the Fairhall Golf Club the use of a cherry picker was required (Fig. 28.7).

It is likely that different patterns of aquifer pressure exist in each of the aquifer pockets, although there are no long-term records of how these compare with fluctuations at the main MDC monitoring well 2022 representing aquifer Pocket B.

Well 0994 located near the southern bend in Benmorven Road and representing Pocket C, has been monitored intermittently over many years. When drilled in winter 1980, this well had a positive artesian level of 0.2 metres. Groundwater elevations have varied at well 0994 since 1985, until it ceased being pumped in about the year 2000. Because this was a pumping well there is a clear seasonal cycle of a summer fall in levels, followed by a recovery in winter and spring. For this reason the record is not ideal for measuring the background or natural variation in level at Pocket C.

**Figure 28.5: Benmorven Aquifer artesian pressure tests. The red arrow denoting the static or resting level around five metres above the general groundlevel**

The final measured elevation of around 22 metres in early 2007 after several years of non-use shows aquifer levels haven't recovered to their 1980 artesian status of about 33 metres elevation above mean sea-level. An overall fall in aquifer levels of around 10 metres is consistent with what has been observed at the main MDC monitoring well at Morven Lane.

## Hydraulic properties

A relatively large number of aquifer tests have been conducted on wells tapping the Benmorven Aquifer. This reflects interest in understanding its hydrology during the 1980s and 1990s, when demand for groundwater resources was taking off. The results from the aquifer tests show that the Benmorven Aquifer has relatively low transmissivity and storage values. Transmissivity values varied from 8 to 240 $m^2$/day. Aquifer storage values were mostly of the order $10^{-4}$ or $10^{-5}$.

## Groundwater chemistry

Groundwater quality in the deeper systems of the Southern Valleys catchments is naturally poorer than for the Wairau Aquifer. Samples from the Benmorven area are relatively unique chemically for several reasons. Firstly, the aquifer has lower rates of aquifer throughflow and shows the presence of marine sediments with naturally high levels of readily dissolvable sodium and chloride. This leads to more mineralised groundwater than elsewhere. Secondly, the confined aquifer type isolates groundwater from the atmosphere and as a consequence of the lack of oxygen, reducing conditions exist. This allows salts such as iron and manganese to become soluble in groundwater which results in staining of the steel headworks of wells as the older groundwater oxidises on arrival at the surface and comes into contact with the atmosphere (Fig. 28.8) .

There are also significant differences within the chemical composition of Benmorven Aquifer water itself, which supports its fragmented structure identified by well

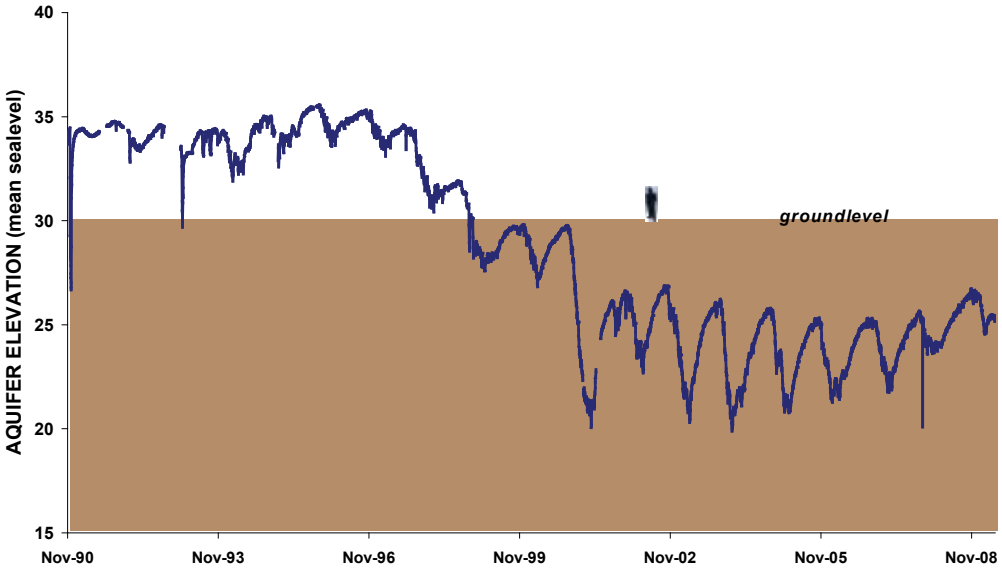


**Figure 28.6: Well 2022 level variation 1990-2008**

testing. Generally groundwater from Pocket C has more evolved groundwater compared to groundwater from Pockets A or B.

Well 0874 located near the bend in Benmorven Road and in Pocket C has highly mineralised water with a chemistry that is dominated by sodium and chloride (Fig. 28.9). The higher than expected levels of calcium are likely to reflect the carbonaceous shells or micro-fossils found in the sediments. Sulphate has been consumed through naturally occurring reduction reactions.

Water from well 2022, representing Pocket B, is more dilute than the water from Pocket C (Fig. 28.10). Not only are the fractions of the major ions present in groundwaters significantly different, but so are the actual concentrations. For example levels of chloride represented by the yellow band are 10 times higher in well 0874 compared with well 2022 groundwater.

Overall the chemistry of Benmorven groundwaters is consistent with medium to long residence times underground.

**Figure 28.7: Measuring artesian pressures in Benmorven Aquifer in 2000**

The isotopic signature of local groundwaters were first sampled in 1974. Resampling of well 0874 in 2006, and a review of all measurements by GNS Science, led to a revised groundwater residence time of greater than 435 years. This is considerably older than previous estimates of groundwater age of around 40 years. However the original assessment of the source of recharge being predominantly valley streams with a component of rainfall is unchanged.

Another feature of Benmorven groundwater is the presence of methane gas ($CH_4$). Methane was recorded at a relatively shallow depth in well 0887, and at around 20 metres depth at well 1647. Methane was detected during well construction when it ignited during the welding of casing.

Methane is generated by the biochemical reduction of organic matter in the absence of oxygen. Its presence is a good indication of advanced reducing conditions, meaning groundwater is depleted in oxygen. It also implies that the water has been underground for a long time.

Organic matter in the form of wood is described twice on the well log for well 1647. While there is no mention of wood at well 0887, it may have been destroyed during the drilling process, as it commonly occurs

**Figure 28.8: Staining on Fairhall Golf Club well headworks**

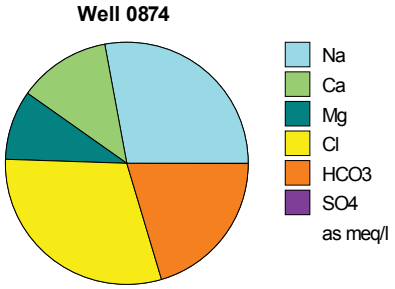


**Figure 28.9: Well 0874 Groundwater chemical composition**

in local wells. The presence of methane is consistent with the conceptual understanding of the Benmorven Aquifer as a relatively closed groundwater system with old water and evolved geochemistry.

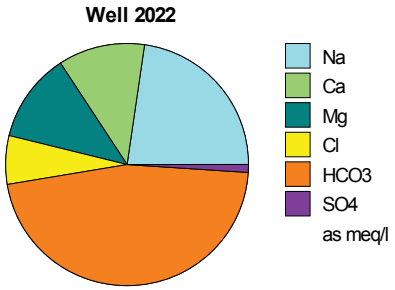


**Figure 28.10: Well 2022 Groundwater chemical composition**

## References

Marlborough District Council, 1995. Groundwater Resources and Issues of the Benmorven Aquifers System. Unpublished internal report.

GCNZ – Woodward Clyde Ltd, 1991. Pumptest report of well 2096