Chapter 29: Fairhall-Brancott Valley Aquifers

Introduction

Two aquifer systems exist in the Fairhall-Brancott Valley (Fig. 29.1) with the largest of the systems being the Brancott Aquifer and the Fairhall River Gravels Aquifer (FRGA) being a smaller riparian aquifer associated with the Fairhall River channel.

The Fairhall-Brancott Valley was the first area in Marlborough to convert to viticulture in the early 1970s and early exploration for groundwater in the late 1970s and early 1980s, met with limited success. As a result a decision was made to transport water to the area from a wellfield located eight kilometres to the north. This same well continues to provide water to irrigate a significant proportion of vineyard in the middle section of the Fairhall-Brancott Valley.

The limited success in locating groundwater in the late 1970s deferred any further attempts at deep drilling until the late 1980s, when there was renewed demand for water to irrigate new vineyards in the area.

Groundwater systems

The Fairhall-Brancott Valley is formed of alluvium deposited by the Fairhall River. Most of the valley floor is formed of impermeable claybound gravels belonging to the Speargrass Formation. This formation hosts the Brancott Aquifer, which explains the low yield of wells tapping this groundwater system.

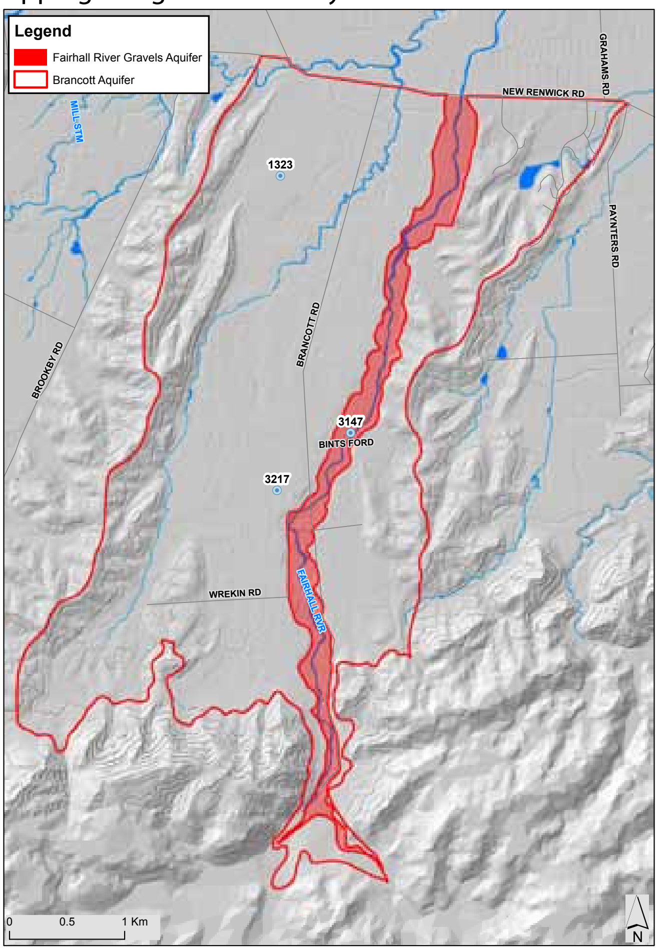

Figure 29.1: Fairhall River Gravels and Brancott Aquifers

The Fairhall River Gravels Aquifer (FRGA) flows through a far more permeable gravel layer, incised into the upper two to three metres of the Speargrass Formation. This thin veneer of gravel has been reworked by the Fairhall River, sluicing out the fine clays thereby increasing its permeability. The thin layer forming the FRGA supplies numerous domestic, stock and irrigation wells. While the narrow thickness of the aquifer makes it vulnerable to over-pumping, it refills quickly when the Fairhall River flows strongly. The FRGA groundwater is so close to the surface that many of the wells were excavated and formed of concrete liners (Fig. 29.2).

Brancott Aquifer

Prior to the late 1980s very few wells tapped the Brancott Aquifer. Successful production wells are generally greater than 30 metres in depth, and most provide yields of less than 10 m^3/hour. The wells often needed to be rested, allowing water levels to recover, to maintain even modest flows. This is especially so over summer when there is competing demand for groundwater resulting in neighbouring well interference.

Between the late 1980s and 2000, a series of deeper wells were drilled to supply groundwater for newly established vineyards, mostly near the southern hills. The maximum known drilling depth reached was 141 metres. Several of the more southern wells such as 3051 and 3073 intercepted the basement greywacke rock. This isn't surprising as greywacke rock forms the local ranges and can be seen outcropping along Brancott Valley Road south of the road bridge.

Based on the records from wells, three broad groundwater bearing layers have been identified. The water bearing layers are not continuous. Rather they are a series of groundwater bearing bodies scattered throughout the alluvium. The concept of a series of groundwater bearing bodies is supported by the significant differences in aquifer water levels across the depth of most wells.

Figure 29.2: Fairhall River Gravels shallow well 1211

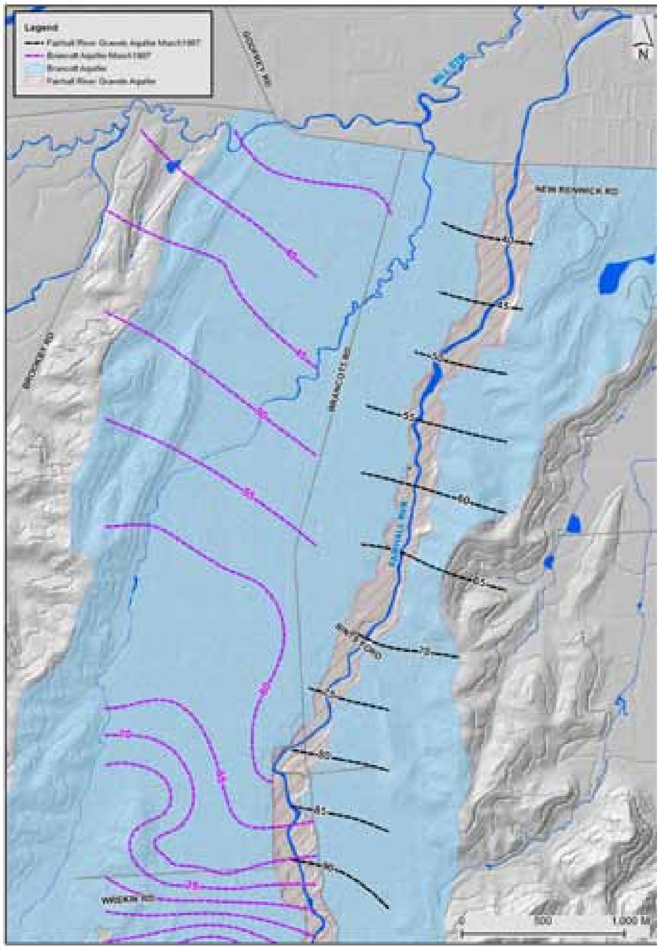

Figure 29.3: Fairhall River Gravels and Brancott Aquifers groundwater elevation March 1997

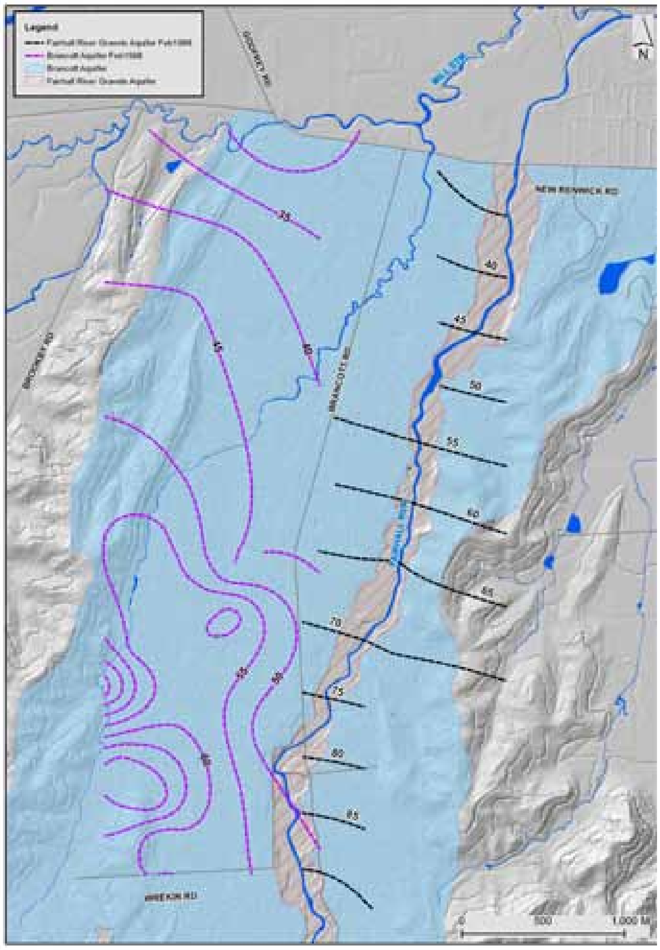

Figure 29.4: Fairhall River Gravels and Brancott Aquifers groundwater elevation February 1998

Recharge and flow patterns

The predominant groundwater flow is in a northwards direction from high to low elevations (Fig. 29.3). The groundwater table lies at elevations of around 100 metres in the Wrekin Road area, and about 30 metres at New Renwick Road. This equates to a relatively steep hydraulic gradient from north to south of 14 metres vertical fall per kilometre. This compares to a gradient in the Wairau Aquifer beneath Blenheim of two metres per kilometre. While this results in rapid drainage of water through the permeable gravels forming the FRGA, the impermeable nature of the Brancott Aquifer sediments limits the rate of horizontal flow.

Due to seasonal variations in recharge and pumping, aquifer levels don't stay the same but vary from spring to summer. In the extremely dry conditions experienced during early 1998, groundwater elevations were shown to have been distorted by pumping (Fig. 29.4) This distortion has the effect of increasing the vertical separation between water in the Fairhall River Gravels Aquifer and the underlying Brancott Aquifer to more than 20 metres. Brancott Aquifer levels in the Wrekin Road area dropped by about 15 metres between March 1997 and February 1998. Not only are there horizontal differences in aquifer levels, but also vertical differences based on well levels.

The trend in static water level with depth indicates a secondary flow pattern exists, involving downwards flow nearest the ranges, and upwards pressure in the north. In other words, the depth below the surface to groundwater increases for wells located in the southern half of the Brancott Aquifer (Fig. 29.5). The opposite occurs around New Renwick Road where historically artesian well levels were once common place. This

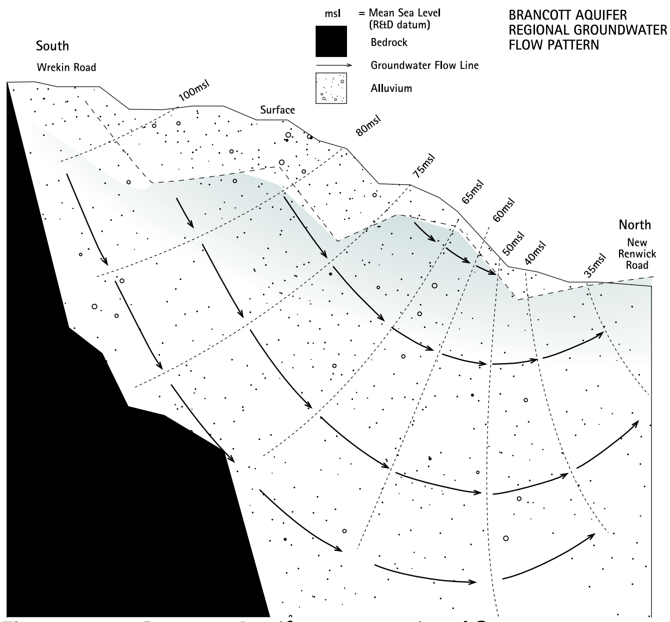

Figure 29.5: Brancott Aquifer cross sectional flow pattern

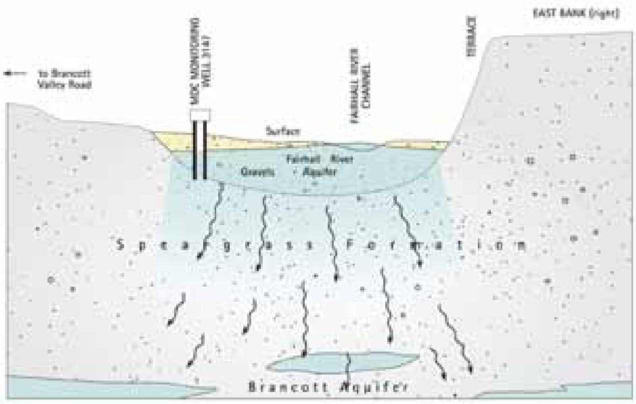

Figure 29.6: Brancott Aquifer Winter recharge mechanism

circulation pattern is common amongst groundwater systems, and is a natural phenomenon that relies on a combination of factors to occur. It reflects a downward hydraulic grade in the recharge area to the south, and an upward hydraulic gradient in what is commonly referred to as a discharge zone, to the north.

Geological structure also plays a part, with a higher degree of confinement further north caused by impermeable clays. Free flowing well conditions are generated by recharge entering the aquifer at a high elevation along Wrekin Road, relative to the confining layers further north where it is pressurised. This pattern is less pronounced today compared to the 1980s due to pumping reducing pressures and modifying the original flow pattern. Care is also needed in interpreting aquifer pressure differences in deeper Southern Valleys aquifer wells because of the presence of long well screens. These mean it isn't possible to measure pressure at a discrete point, only an average over the section of the well that is screened.

During typical summer and autumn conditions there is limited vertical interaction between the two aquifer systems. The Fairhall River becomes perched above the Brancott Aquifer and separated by dry, low permeability sediments.

The exact way in which the Brancott Aquifer is recharged is not yet fully understood. What is currently known is based on long term records from the MDC monitoring well 1323 in the middle reaches of the valley. Monitoring records show that water levels slowly recover following the end of the summer irrigation season. Brancott Aquifer water levels only respond to flows of greater than around 100 l/s in the overlying Fairhall River. This largely reflects the layer of sediments separating the Fairhall River from the Brancott Aquifer. These intervening sediments absorb seepage of recharge water until such time as they are saturated and there is sufficient flow to penetrate downwards to the underlying Brancott Aquifer (Fig. 29.6). As a consequence the process of Fairhall River water or rainfall recharging the Brancott Aquifer is not instantaneous. Aquifer recharge relies on the saturation of these intermediate sediments before there is a direct flow connection.

Rises in Brancott Aquifer water levels coincide with larger or sustained flows, which often occur in spring (Fig. 29.7).

For most of the year the Fairhall River is ephemeral and naturally loses all channel flow to groundwater south of Middle Renwick Road. In summer the channel is regularly dry north of the road bridge near the intersection of Wrekin and Brancott Valley Roads.

Flow in the Fairhall River north of Middle Renwick Road is a relatively rare occurrence, happening only once or twice a year, mostly in winter or spring when there is sufficient catchment runoff to overcome natural leakage to the underlying gravels.

The introduction of the Southern Valleys Irrigation Scheme (SVIS) in 2004 has reduced reliance on Brancott Aquifer groundwater by irrigators. As a consequence Brancott Aquifer levels have largely recovered to their mid 1990s level (Fig. 29.8).

The recovery is partly due to a reduction in localised pumping close to this monitoring well and may not be representative of the wider Brancott Aquifer, particularly the southern cluster of wells around Wrekin Road. It is likely that levels will fluctuate in future in response to variations in aquifer demand, changes in catchment vegetation or rainfall patterns.

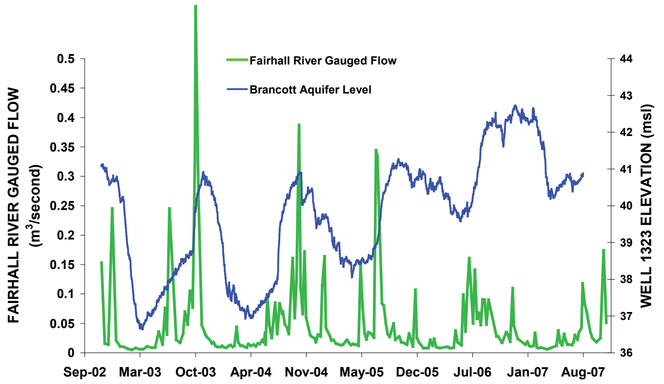

Figure 29.7: Fairhall River interaction with Brancott Aquifer

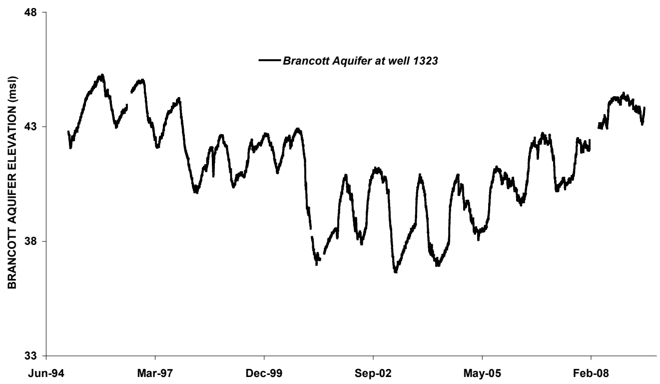

Figure 29.8: : Brancott Aquifer variation 1995 – 2009

Hydraulic properties

Aquifer tests for Brancott Aquifer wells show the groundwater system is low yielding by Wairau Plain standards. Transmissivity values are less than 100 m^2/day and storativity values of the order of 10^{-4}.

In common with other Southern Valleys Aquifers, some tests show the presence of barrier boundaries. These boundaries reflect the localised nature of water bearing layers making up the Brancott Aquifer. For example the transmissivity of well 1241, located near Wrekin Road, declined from 160 to 67 m^2/day based on the results of a 1989 test.

Fairhall River Gravels Aquifer

Within the confines of the Fairhall River's narrow floodplain, a riparian groundwater resource exists. The aquifer is known as the Fairhall River Gravels Aquifer (FRGA), and supports a number of irrigation takes as well as stock or domestic purposes. The FRGA relies on losses from the associated Fairhall River for recharge. Once channel flow stops the aquifer slowly drains therefore the FRGA is not a reliable source of groundwater during typical summer conditions because of its limited storage capacity. While there is typically no channel flow, some groundwater flow will be occurring within the gravels several metres below the surface (Fig. 29.9).

The FRGA adequately meets all water demands placed on it earlier in the season when there is channel flow. However, since the 1980s, abstraction exceeds recharge from mid January onwards. With the introduction of the Southern Valleys Irrigation Scheme (SVIS) in 2004, demand on the FRGA as a primary source of supply has declined.

Recharge and flow patterns

Much of what is known about the Fairhall River Gravels Aquifer is based on an intensive field study carried out in the early 1980s by Mr. J. Cunliffe of the MCRWB. The study found that the source of water for the gravels of the Fairhall River floodplain at any time of the year is primarily drainage from the upper Fairhall River Catchment itself.

Figure 29.9: Fairhall River upstream of New Renwick Road

Figure 29.10: Fairhall River Gravels Aquifer ponds

In a typical season the quantity of water draining from the catchment decreases as summer progresses. This is reflected in channel flow receding upstream in a southerly direction. Under these conditions gravels underlying the channel become partially saturated. In the absence of further rain in the upper catchment, groundwater flow is sustained by water stored in the gravels.

A reduction in catchment drainage is reflected in the progressive reduction in the saturated depth of the gravels within the floodplain. Coupled with this is a reduction in the amount of water flowing through the gravels of the floodplain. On the 29th of March 1982 for example, this underflow was calculated to be of the order of 15.5 m^3/hour. Testing during this investigation demonstrated that hydraulic connection existed between shallow wells tapping these gravels, and recharge originating from upstream. There are no independent sources of recharge such as springs or faults.

Knowledge of the subsurface flow within the gravels beneath the dry channel bed in the 1980s, led a local landowner to excavate a series of ponds to access the water for irrigation purposes (Fig. 29.10). These ponds illustrate the nature of the FRGA and its unconfined structure. It is important to realise these ponds do not store water, but are effectively oversized wells. Aquifers make superb water stores because evaporation losses are low, but these ponds do expose groundwater to the sun and wind. The ponds are only a maximum of several metres deep, emphasizing the thin nature of this narrow, channel type aquifer.

The other distinctive feature of the FRGA system is its small area and hence limited storage. This, in conjunction with a relatively steep grade, means its permeable gravels tend to naturally drain quickly in the absence of catchment recharge. Pumping reduces groundwater levels further. Conceptually the shallow gravels act as a pipe, transmitting water relatively quickly compared to the slow rate of movement through the claybound valley floor sediments of the underlying Brancott Aquifer.

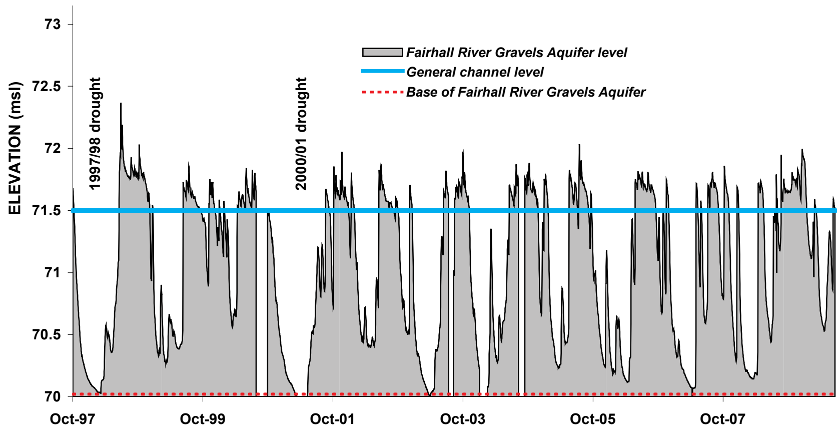

Figure 29.11: Fairhall River Gravels Aquifer level record

Well yields are very sensitive to Fairhall River flow or in its absence, the rate of underground throughflow. Research during the dry summers of the early 1980s clearly demonstrated that this riparian gravel aquifer can only sustain a small number of irrigation sized takes throughout the dry summer months. This conclusion was supported by similar experiences during the subsequent 1997/98 and 2000/01 summer droughts.

In late 1997, the MDC established a permanent groundwater level recording station to measure variation in the FRGA. The site is on the left bank of the Fairhall River at Bints Ford approximately half way up the valley.

Over a ten year period from 1997, the full water level record for well 3147 shows a series of sharp rises in levels corresponding with Fairhall River floods followed by a pattern of rapid drainage or recession (Fig. 29.11).

Smaller floods generated by runoff in the headwaters of the catchment can take a while to travel downstream and be observed at the MDC Bints Ford recorder, especially over summer. While there is always likely to be some groundwater flow at depth, the progress of the wetted front at the surface can often take days to move from the gorge to the monitoring site.

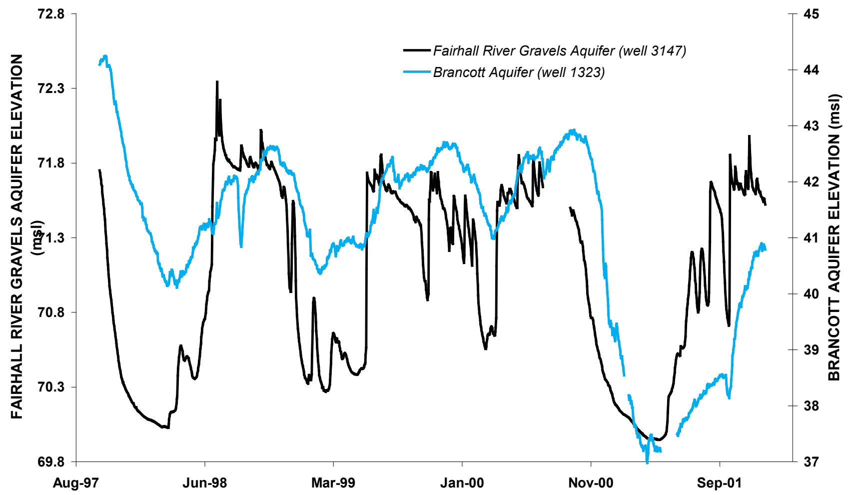

Figure 29.12: Fairhall River Gravels Aquifer versus Brancott Aquifer levels

The Brancott Aquifer has a much larger variation in aquifer levels compared to the FRGA because levels in the FRGA are constrained by the base of the channel gravels. Groundwater levels varied by ten metres in the deeper Brancott Aquifer compared to just over two metres in the shallow FRGA over a five year period (Fig. 29.12).

Hydraulic properties

Aquifer transmissivity values ranging from 100 to 1,500 m^2/day have been calculated from pumping tests carried out during early 1982. Higher values correspond to higher river channel flows. Transmissivity values are relatively high compared to those measured for the Brancott Aquifer. However, the high parameter values are offset by the small volume of water stored within the FRGA. This is especially so in late summer when the Fairhall River is typically in recession. Under these late summer conditions the FRGA is a less reliable water source than the deeper lying Brancott Aquifer, which has greater storage because of its larger size and thickness.

Even though the gravels forming the FRGA are more permeable than those of the underlying Brancott Aquifer, they still have a high clay content compared to the alluvial gravels forming the high yielding Wairau Aquifer (Fig. 29.13).

Groundwater chemistry

Older more chemically evolved groundwater is associated with sluggish flow at depth in the Brancott Aquifer. More dilute, younger groundwater is linked to the riparian FRGA near the surface.

The shallow FRGA groundwater from well 3147 is classified as Calcium-Sodium-Magnesium-Bicarbonate type and is typical of Fairhall River water from its origin. (Fig. 29.14). By contrast, groundwater from well 3217, which is screened at a depth of between 55 and 140 metres below the surface, has a higher percentage of sodium and chloride (Fig. 29.15). This water retains a significant amount of sulphate which is unusual for such a deep well with a low dissolved oxygen content of 0.6%. It also has a smaller fraction of magnesium which is also unusual.

Well 3217 has a long screen and draws groundwater from a range of depths. It is possible that shallower water with higher nutrient levels is drawn in by well

Figure 29.13: Clay bound gravels of the Fairhall River Gravels Aquifer

pumping, or has leaked down the casing from above. The elevated arsenic levels that have been measured at this well are indicative of reduced chemical conditions and possibly older groundwater.

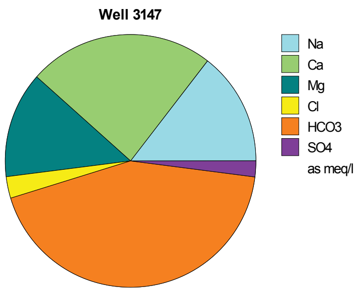

Figure 29.14: Well 3147 Groundwater composition

Monitoring shows that conductivity increases with depth indicating higher levels of dissolved salts associated with older water.

The presence of hydrogen sulphide gas at wells: 1879, 1895, 2301, 3217, is indicative of moderately advanced reducing conditions in the deeper layers of the Brancott Aquifer.

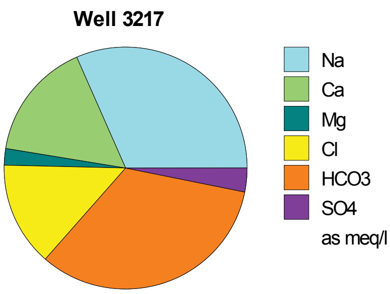

Figure 29.15: Well 3217 Groundwater composition

Reducing conditions also commonly lead to elevated or high levels of iron and manganese in some deeper wells, which in turn can cause staining for domestic water users. Sulphate levels in deep groundwater are low as a result of the reducing chemical environment.

Deeper Brancott Aquifer groundwaters appear to be less mineralised than those from the Benmorven Aquifer, but are more evolved than Omaka Aquifer groundwater. These differences primarily reflect the relative degree of confinement.

Generally nutrient levels in the Fairhall River Gravels are low. However measurements of water from a series of springs or shallow wells in the Lower Fairhall-Brancott Valley in the 1970s and late 1990s, contained moderate to high levels of nitrate-nitrogen. Isotope fingerprinting indicated an animal rather than a fertiliser source. But at the time these measurements were made, land was commonly being converted to irrigated vineyards and away from pastoral farming.

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