Chapter 38: Northbank Riparian Aquifers

Introduction

The Northbank collectively refers to the series of small tributary river catchments which drain the southern flanks of the Richmond Ranges on the north bank of the Wairau River. They extend from the Pukaka River near Cloudy Bay in the east, to Top Valley in the west.

Groundwater is less commonly used than surfacewater in the Northbank catchments as streams and rivers provide the small volumes generally required during most seasons. Overall water demand is lower than elsewhere in the province because of the lower density of settlement, less intensive or irrigated agriculture and higher rainfall. The average annual rainfall is one metre or more across all of the Northbank catchments compared to 660 mm in Blenheim.

While the Northbank area hasn't experienced the growth in irrigated agriculture of the main Wairau Plain or Marlborough Sounds catchments, water demand has increased slightly through growth in rural residential settlement, vineyards and pasture irrigation.

Figure 38.1: Wairau Valley looking upstream with Fabians/Bartletts Creek on the right. The dotted red line shows the location of the river terrace that separates the lower Wairau River influenced alluvial flats from the elevated terrace which is dominated by local rainfall or Fabians/Bartletts Creek flow. Arrows indicate the likely flow path of subsurface Wairau River water inferred by isotope measurements.

A highly visible physical feature which separates Northbank water from Wairau River flow, is the alluvial terrace that runs more or less continuously along the base of the Richmond Ranges from the mountains to Tuamarina (Fig. 38.1). This terrace was formed by the Wairau River eroding downwards into sediments deposited in the last glacial period.

Groundwater systems

Rivers or streams draining the Richmond Ranges on the north bank of the Wairau River commonly flow in their upper reaches, where bedrock is close to the surface. In their lower reaches the rivers and streams lose water to the permeable gravels and becomes ephemeral. The permeable gravels that store the surface flow losses reach their maximum thickness where they join the Wairau River (Fig. 38.2).

Groundwater often re-emerges to form springs or wetlands at the foot of the ranges close to the Wairau River. This water then contributes to the flow of the Wairau River.

A groundwater mixing zone exists between Wairau River water and Northbank flows, with the boundary shifting seasonally depending on the relative inputs of water from each source. Unlike the opposite south bank of the Wairau, where groundwater is predominantly recharged by local hill country runoff, Wairau River water influences Northbank aquifers at Top Valley and Fabians/Bartletts Creek.

Wells are scarce on the Northbank because of the reliance on surfacewater. As a result less information exists than for other areas of Marlborough. The wells that do exist are relatively shallow by Marlborough standards, as groundwater is close to the surface.

Existing wells are restricted to the lowland alluvial floodplains, with most providing small volumes of groundwater for stock or domestic purposes. Wells are often located near rivers or wetlands to maximise the chance of intercepting sub-surface flow when conditions are drier. Increasingly, infiltration galleries

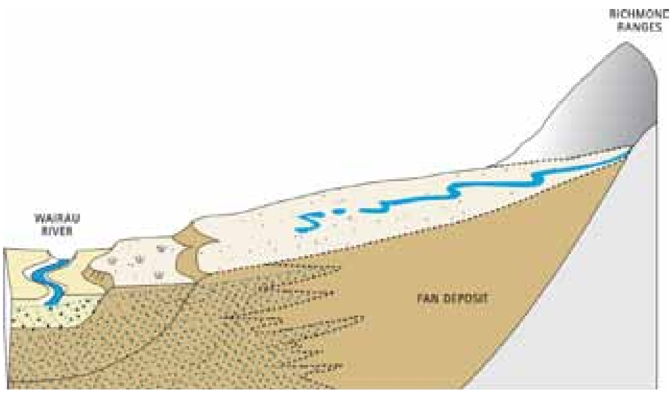

Figure 38.2: Northbank Riparian Aquifer conceptual model

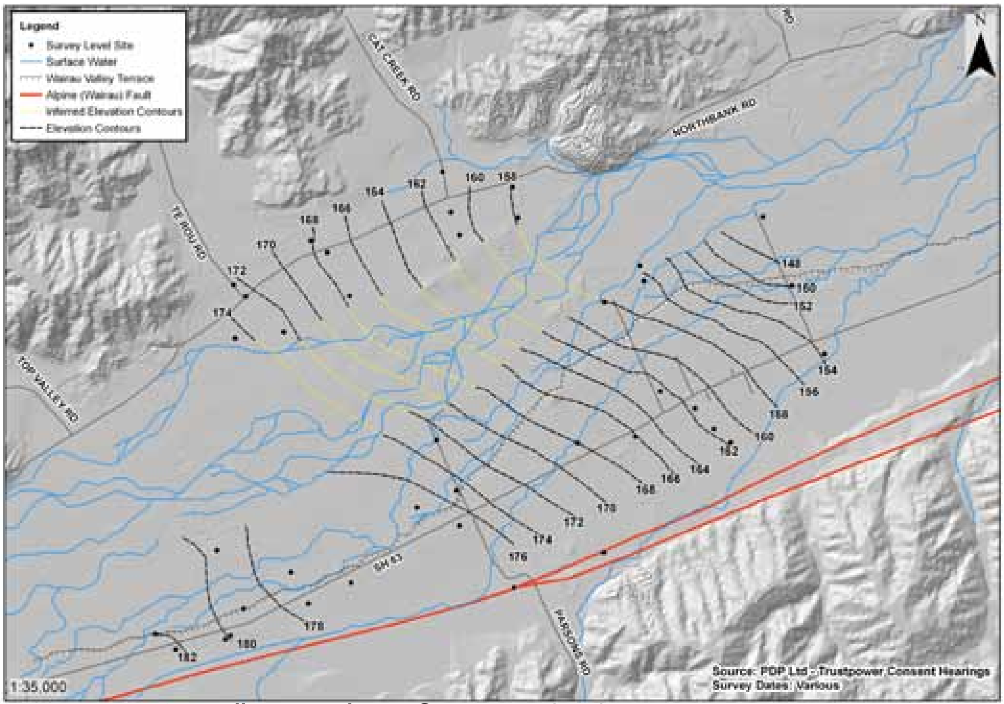

Figure 38.3: Wairau Valley groundwater flow pattern (PDP)

and deeper conventional wells are being installed for vineyard and pasture irrigation.

Northbank catchments have characteristically low summer yields because only a small volume of water can be stored by local scree deposits and maintain the base flow of streams.

Recharge and flow patterns

Groundwater underlying the Northbank alluvial flats below the main terrace appears to receive recharge from a number of sources. In addition to Northbank runoff and rainfall, Wairau River water also penetrates inland. Contours of groundwater elevation, compiled from a series of different surveys, show that water is leaving the Wairau River and travelling under the river flats to the north (Fig. 38.3)

The reasons for the greater influence of the Wairau River remain uncertain. The long term tilting of the Marlborough Sounds geological block would tend to force the Wairau River channel towards the north bank. Alternatively it could also be a short term effect reflecting the current position of the Wairau River channel.

Groundwater chemistry

Based on the 2009 survey and report by University of Canterbury researcher James Botting, there is little difference between the chemical composition of water from the Wairau River and that of the rivers draining the North Bank tributaries, or their associated groundwater. This points to a high degree of mixing of stream and groundwaters within the Northbank catchments.

All waters are chemically dilute meaning they have low levels of dissolved salts, and being close to the surface or atmosphere, are oxidised. They are also relatively young meaning they have fallen as rain or been lost from river flows within several years of becoming groundwater.

Subtle differences exist between surface waters and nearby well waters. Groundwaters tend to have slightly higher levels of dissolved salts than nearby surface waters because of their longer residence time in contact with the minerals forming local rocks. Inputs from landuses account for most of the differences in water quality.

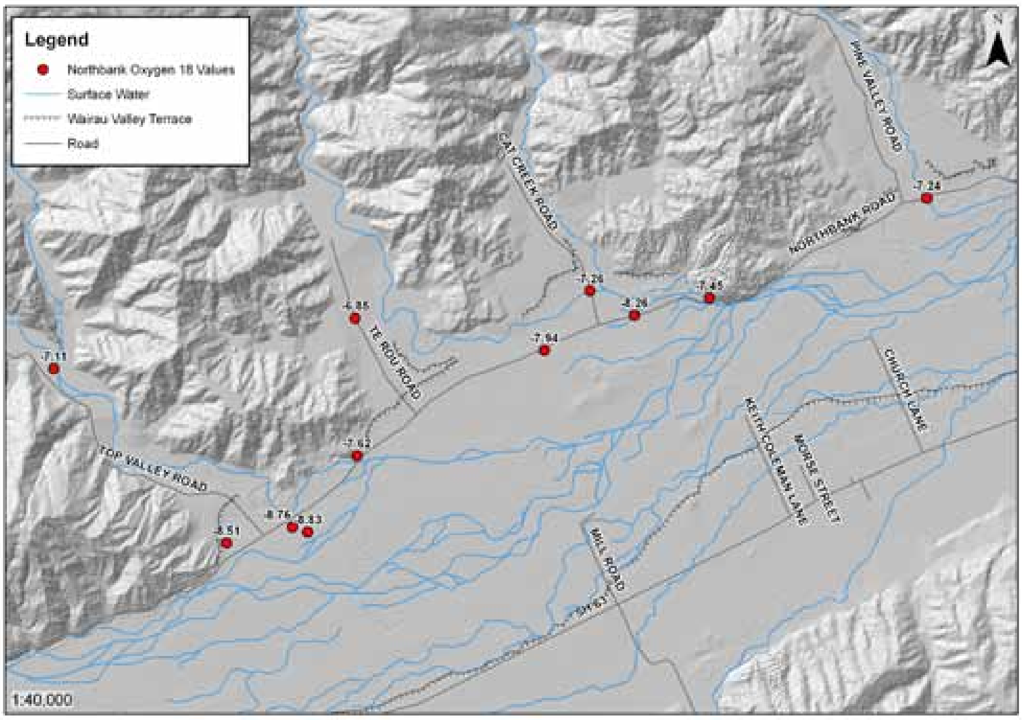

Figure 38.4: $\delta^{18}O$ Ratios of Northbank waters (Botting - 2010)

Figure 38.5: Northbank groundwater, largely derived from river water, intercepting the surface at an excavated pond. River terrace marked by the arrow in middle of the photo.

The similarity in chemical composition makes it difficult to distinguish between waters. However, the $\delta^{18}O$ ratios for Northbank and Wairau River waters are distinct which allows its origin or degree of mixing to be determined. Based on the results of the 2009 field survey, it was determined that $\delta^{18}O$ values of around -8.50 ‰ were found in Wairau River water and that local rainfall or runoff from the North Bank catchments exhibited values varying from -6.50 to -7.00 ‰ (Fig. 38.4). Waters lying between these groups were a mixture of high altitude derived Wairau River water and lower level rainfall or runoff (Fig. 38.5).

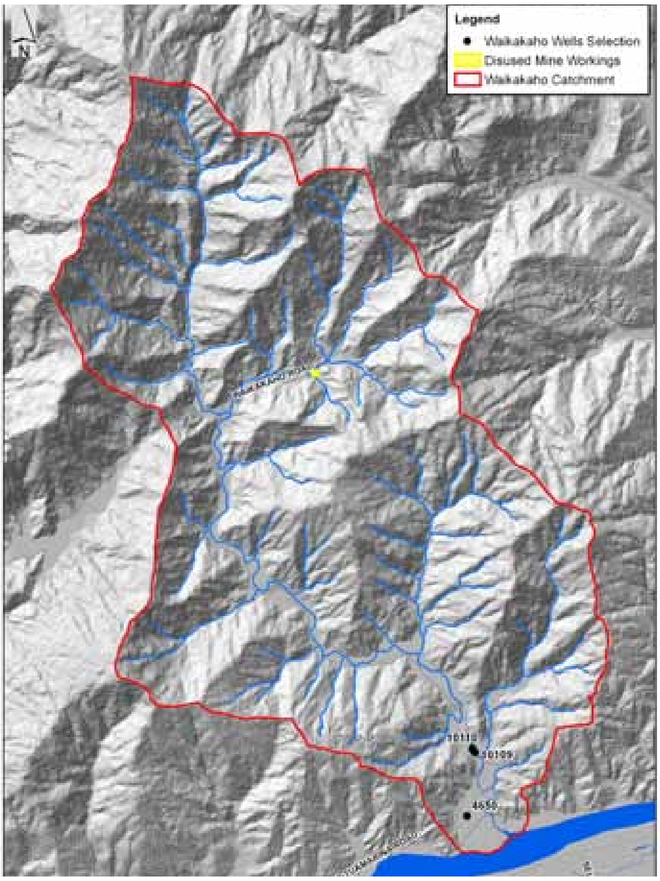

Figure 38.6: Waikakaho River Catchment boundary

Waikakaho River Gravels Aquifer

The Waikakaho River Valley has been the focus of hydrological investigations recently as demand for water in the area has increased and as a result there is now a greater understanding of water resources in this area.

The Waikakaho River Valley lies opposite Wratts Road on the north bank of the Wairau River (Fig. 38.6). The majority of the catchment is hilly and formed of bedrock, with only the valley floor being filled with aquifer forming sediments.

Pasture or crop irrigation and higher densities of human settlement have increased water demand on the small area of the catchment made up of river flats. Historically few wells existed locally, with most supplying small volumes of water all year round for stock water or household use.

Little was known about the hydrogeology of this area until recently when a permanent Waikakaho River flow recorder and monitoring well were established by the MDC in the middle to lower reaches of the valley in 2009.

The Waikakaho River Gravels Aquifer is formed by a narrow band of alluvial gravels squeezed between outcropping basement rock on either side, and recharged by leakage from the overlying Waikakaho River (Fig. 38.7).

Based on the drillers descriptions during the construction of the 30 metre deep MDC monitoring well 10110, the alluvium consists predominantly of yellow clay, gravel or sand eroded from the local schist rock.

Channel flow is intermittent, especially in summer with pools separated by dry reaches. River water is lost to the deeper gravels where it becomes groundwater and

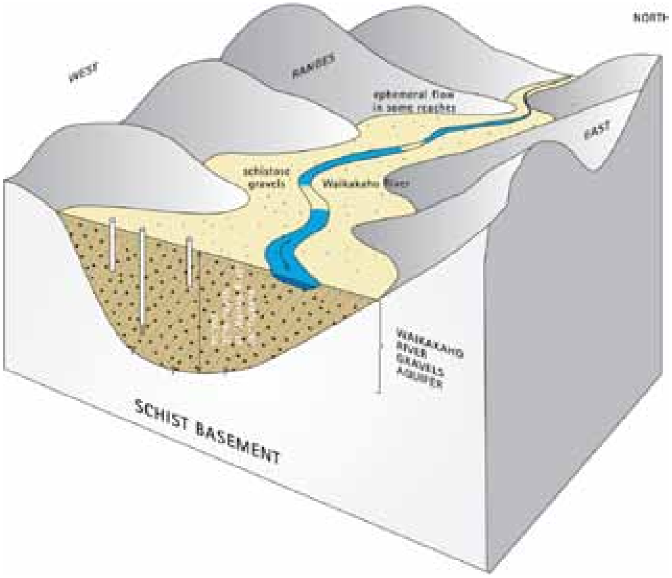

Figure 38.7: Waikakaho River Gravels Aquifer conceptual model

Figure 38.8: Schist outcropping in the base of the Waikakaho River

the channel ceases to flow. Where basement rock is close to the surface it forces groundwater upwards and channel flows appears at the surface.

This interconnectedness of river and groundwater is confirmed by the similarity in the $\delta^{18}O$ values for the MDC permanent monitoring well water, and nearby Waikakaho River water. The aquifer depends on the reliability of channel flows in summer to provide recharge.

The thickness of the alluvium is known to vary depending on location, and is variable in the vicinity of the MDC monitoring site (Fig. 38.8). Outcropping schist basement rock is seen at the MDC flow recorder site. However, the MDC test well 10110, located eighty metres away, did not intercept schist basement when drilled to a depth of 30 metres.

Well 4650 located in the lower valley near the Tuamarina-Kaituna Track, was drilled in 2007 to a depth of 19 metres without intercepting basement rock.

Recharge and flow patterns

A close link exists between Waikakaho River flow and groundwater in the surrounding gravels. This was demonstrated as long ago as the 19th century when gold mining operations had to use pumps to keep underground tunnels in the alluvial gravels dewatered so they could be worked.

Groundwater flow closely mimics channel flow, draining southwards towards the Wairau River under the influence of gravity, and constrained by the basement rock forming the valley sides. The groundwater elevation also shows a close match between the behaviour of groundwater and river water, showing they are hydraulically connected (Fig. 38.9). Water moves backwards and forwards between the river and groundwater depending on the natural conditions that exist at the time (Fig. 38.10).

Waikakaho River flow is the driving force during floods of any size, with levels rising first and reaching higher elevations than water in the aquifer, but receding more quickly. Under these conditions river water is flowing into the aquifer and refilling it quickly because of the limited storage capacity of the gravels.

During flood events of the order of 500 to 1,000 l/s, the elevation of channel water and groundwater can be higher by more than several metres for short periods.

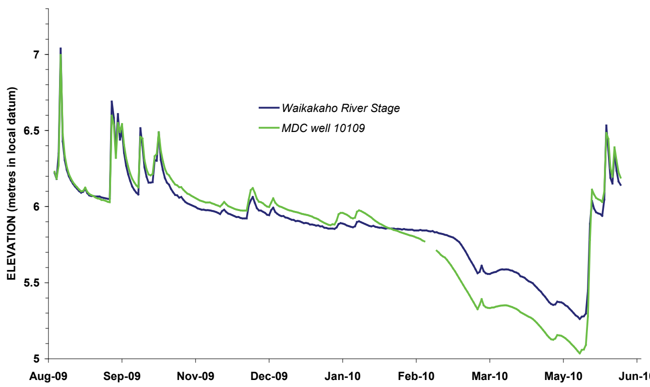

Figure 38.9: Waikakaho River flow versus groundwater elevation

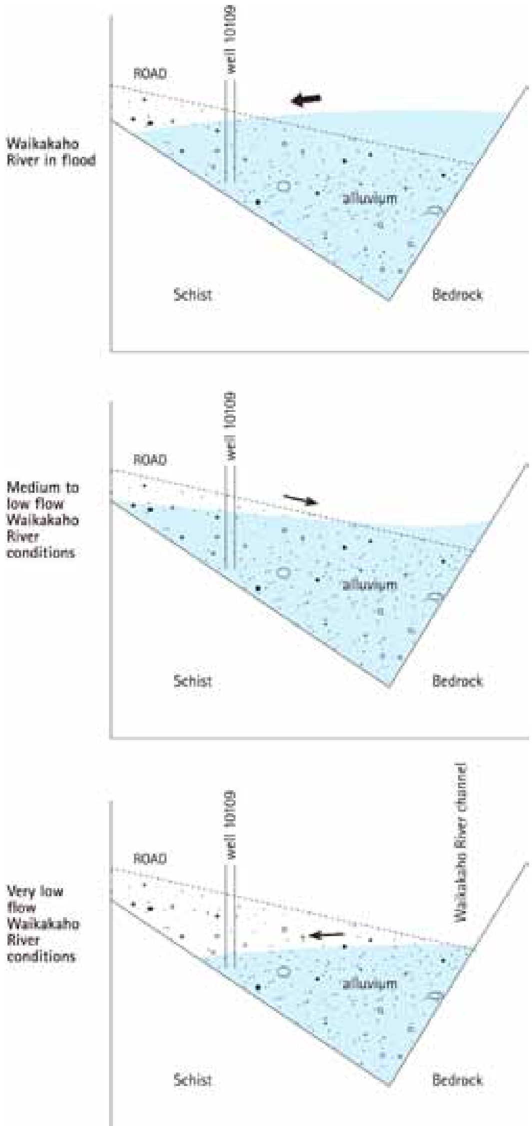

Figure 38.10: Waikakaho River interaction with groundwater

Under medium to low flow conditions the opposite happens, with slightly higher groundwater levels causing flow towards the river. Under the low flow conditions that dominated from October 2009 through to January 2010, aquifer levels were on average 75 millimetres higher than river level. As catchment conditions became drier, the flow direction reversed with the Waikakaho River sitting 250 millimetres above the level in the well (Fig. 38.10).

Hydraulic properties

Unless wells are located a significant distance from the Waikakaho River, the results of aquifer tests are likely to be influenced by channel flow, with transmissivity appearing higher than would otherwise be the case due to river recharge. This influence explains the relatively high well yields in the area. Well logs record a mean specific capacity of 48 m^3/hour/metre, which indicates a mean transmissivity of around 2,500 m^2/day. This is high even by Wairau Aquifer standards.

Two tests were conducted by the MDC on the wells at the flow recorder site to determine the aquifer hydraulic properties of the local gravels. The first test was carried out in winter 2009, and the same constant flow procedure was repeated under low Waikakaho River flow conditions of 29 l/s on the 28th of February 2010. During both tests very high transmissivity values were measured. This was interpreted as showing induced recharge of Waikakaho River channel water in response to groundwater pumping. Because no response was measured at the observation well 10110 during either test, the storage coefficient of the gravel aquifer wasn't able to be calculated.

Another test was carried out in June 2007 on well 4650 near the Kaituna-Tuamarina Track. This 19 metre deep well is located between 230 and 440 metres from the Waikakaho River channel. The well does not intercept basement rock, but has several thick clay layers which are likely to mean it has a semi-confined to confined aquifer structure. Very high transmissivity values of a similar magnitude to those for the MDC test were recorded (MWH – 2007).

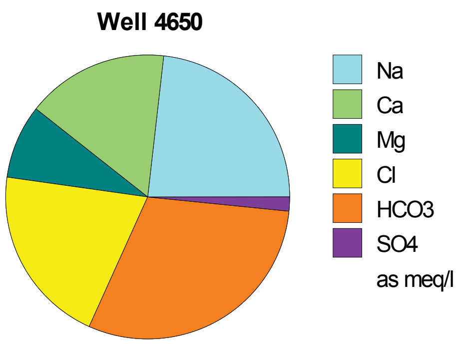

Figure 38.11: Well 4650 groundwater composition

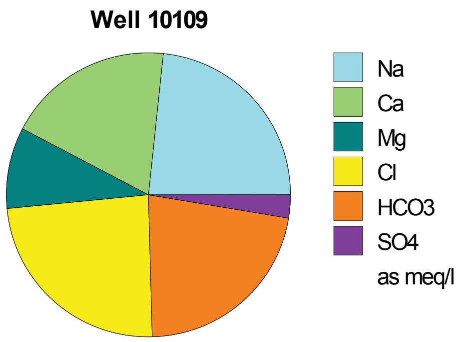

Figure 38.12: Well 10109 groundwater composition

Groundwater chemistry

Samples of $\delta^{18}O$, tritium and dissolved groundwater gases were taken from well 4650 in November 2007 by the MDC to determine the age of local groundwater and its likely origin.

The age of groundwater from well 4650 is very recent with a mean residence time of one year. A young age is consistent with the chemically dilute nature of the groundwater (Fig. 38.11). Some parameters are slightly more evolved than channel water, reflecting its greater depth and longer interaction with the local rocks.

Nitrate concentrations are low in both groundwater and Waikakaho River waters which reflects the small portion of the catchment used for agriculture. The similarity in the chemistry of underground and river water indicates they are effectively one and the same water body.

The chemical composition of groundwater from the MDC monitoring well 10109 is similar in nature to water from well 4650, supporting the concept of an interconnected aquifer linked to the river, with limited chemical evolution (Fig. 38.12). Waikakaho groundwater has a higher proportion of chloride and sodium than Wairau River water or Wairau Aquifer water. While within the Northbank tributaries in general this reflects landuse influences, there may be a mineralogical cause in the Waikakaho area.

In terms of the source of recharge to local groundwater, all well and Waikakaho River water have δ18O ratios between -6.12 and -6.7 ‰, which is taken to be representative of local rainfall or runoff (Morgenstern – 2008).

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