Chapter 31: Omaka River Aquifer

Introduction

The Omaka River is the largest and most westerly of the Southern Valleys catchments. It is elongated in shape and straddles a variety of terrain, from mountains to alluvial plains (Fig. 31.1). The Omaka River flows all year round in its upper reaches where the catchment is formed of relatively impermeable greywacke bedrock. In the lower reaches it is ephemeral during the drier months when all river flow is lost to groundwater.

The seasonal variation in Omaka River flow is the driving influence on the hydrology of the aquifer and downstream groundwater systems as far north as Woodbourne.

Over time various names have been used to describe local groundwater resources. To distinguish it from the Omaka Aquifer in the neighbouring Omaka-Hawkesbury Valley, the groundwater system associated with the Omaka River has historically been known as the Omaka River Valley and more recently, the Omaka River Aquifer.

History of use and investigations

There has been a keen interest in water availability in the Omaka River Valley dating back many decades. Initially most wells were located close to the present river channel and were of a very shallow depth. The shallow depth of the wells and the thin nature of the shallow aquifer limits how far well levels can be lowered.

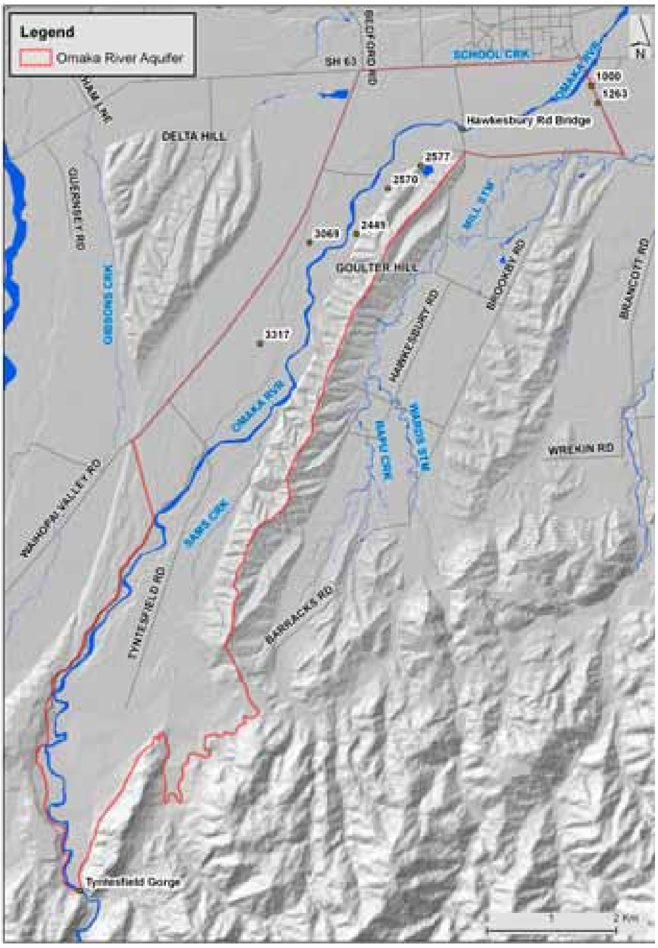

Figure 31.1: Omaka River Aquifer boundary

From the early 1980s onwards deeper drilling occurred as the demand for vineyard irrigation water increased. This resulted in the development of production wells of up to 20 or more metres in depth. Although the deeper wells were lower yielding, they were more reliable than their shallow counterparts in severe droughts.

Notable examples of early deeper wells were well 1000 drilled in November 1980 to a depth of 36 metres, and well 1263 drilled to 40 metres in April 1983. Both wells are located in the Godfrey Road area. The location and target depths of both wells relied on resistivity survey information gathered prior to their establishment.

Surface water takes from the Omaka River became fully allocated in the late 1990s. As a result various landowners explored even deeper for groundwater not hydraulically connected to Omaka River flow, in the hope that this would be exempt from controls. The deepest to date is well 3317, located in the middle reaches of the catchment, which was drilled to a depth of 267 metres. While some water was found at depth, the most productive strata in the catchment lies near the surface and is linked to the Omaka River. Furthermore it is likely that even though water bearing layers are separated from the Omaka River channel by tens of metres of alluvium, the river remains the primary source of recharge for all catchment groundwater.

Successful irrigation bores in this area tap old river channels which form permeable conduits for groundwater to flow towards wells. Generally the deeper wells are located in the lower reaches of the catchment around Woodbourne where the thickest gravel deposits are. In the upper reaches bedrock naturally limits the prospects of locating groundwater to a depth of about 10 metres.

A large downstream user that relies on throughflow of Omaka River Aquifer water is the industrial/municipal complex centred at RNZAF Base Woodbourne. There are also many domestic or stock wells servicing the rural hinterland south-east of Renwick which rely on continued recharge from flow originating from this hydrological system.

Groundwater systems

A sequence of alluvial gravels several hundreds of metres thick have been deposited by the Omaka River over time. Dispersed throughout these sediments are more permeable gravels that form water bearing layers.

Figure 31.2: Omaka River Aquifer cross section

The Omaka River Aquifer is made up of a shallow layer overlying a deep layer. The shallow layer is a riparian type aquifer formed by the thin veneer of recently deposited gravels surrounding the Omaka River (Fig. 31.2). The shallow aquifer layer extends to a depth of approximately 10 metres below the surface and is formed of highly permeable gravels reworked by the Omaka River. The deeper layer includes the sequence of dispersed water bearing material below this to depths of several hundreds of metres.

Yields from wells tapping the shallow aquifer are higher than for the deeper layer because it is essentially an extension of the Omaka River. However, well yields fall off dramatically when the river dries up.

The shallow aquifer is underlain by the deeper aquifer which is tapped by wells 20 metres or more in depth and formed of the impermeable clay-bound gravels belonging to the Speargrass Formation. Both layers merge together in the lower catchment around Woodbourne.

The deeper layer does not represent a discrete aquifer, but a series of semi-independent water bearing bands and their location is often unpredictable (Fig. 31.3).

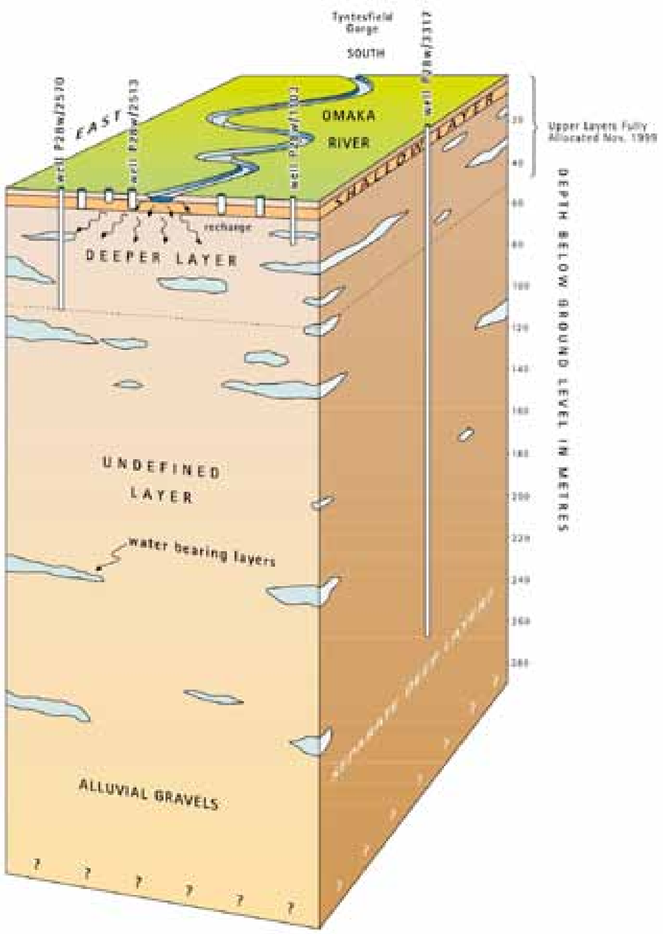

Figure 31.3: Lower Omaka River Aquifer conceptual model

Omaka River interaction with groundwater

The Omaka River is the dominant control on local groundwater hydrology. Tyntesfield Gorge is an area of the Omaka River where the channel is a narrow gorge incised into bedrock. The gorge was chosen by the MDC for its permanent flow recorder site in late 1993 because all catchment runoff can be measured (Fig. 31.4). Below the Tyntesfield Gorge the river changes to an alluvial river bed bounded by terraces and some of the flow is lost to the alluvium as groundwater.

Omaka River flow varies by four orders of magnitude from a minimum of 67 l/s in March 2001 during a 1 in 30 year return period drought, to an estimated 285,000 l/s during a large flood in mid 1994.

The middle reaches of the Omaka River are characterised by a gravel floodplain which varies in width from 30 to 800 metres, and is bounded on either bank by river terraces.

The gravels forming the shallow aquifer layer are extremely permeable and lie at a steep grade. The slope of the Omaka River and its associated groundwater flattens from around ten metres per kilometre at Tyntesfield Gorge, to about three metres per kilometre

Figure 31.4: Tyntesfield Gorge flow recorder site

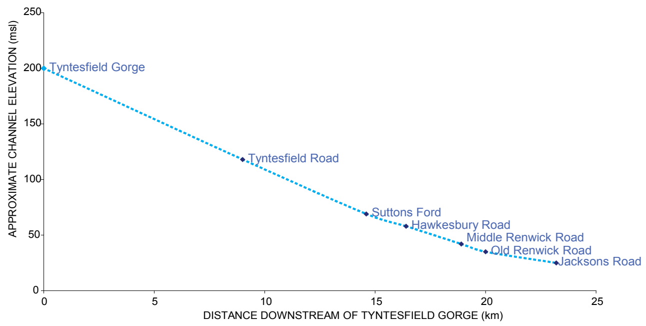

Figure 31.5: Omaka River long section

at Renwick. (Fig. 31.5) The combination of permeable gravels and the steep slope means groundwater drains away quickly.

In its lower reaches downstream of Hawkesbury Road, the river terraces disappear as the Omaka River leaves its hill catchment and forms a large alluvial fan extending to Woodbourne. This alluvial fan coalesces with the more permeable gravels laid down by the Wairau River to the north, and the two aquifer layers merge into one.

The thickness of gravels reaches its maximum at the bottom of the catchment and as a result, most Omaka River channel flow is lost to groundwater during the drier months. During typical summer conditions the channel is generally dry downstream of the Hawkesbury Road bridge. Below this point channel flow disappears into the gravels and becomes groundwater (Fig. 31.6).

The location of the wetted front varies seasonally depending on river flow. The flow extending further downstream in winter or spring, and recedes to the south in summer or autumn. The wetted front can oscillate between Old Renwick Road and Tyntesfield Road, although most frequently flow ends between Hawkesbury and Middle Renwick Road bridges.

Gauging surveys made during the early 1980s show that channel flow declines with distance downstream of Tyntesfield Gorge as water infiltrates into the alluvium (Fig. 31.7). The greatest losses occur downstream of Hawkesbury Road bridge. Even if there is no visible

Figure 31.6: Omaka River flow being lost to groundwater

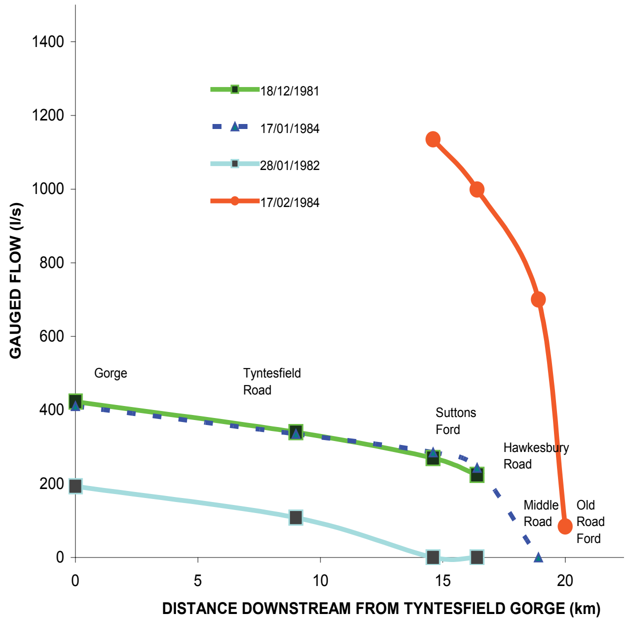

Figure 31.7: Omaka River flow loss profile

channel flow in a reach, there is likely to be groundwater moving below the surface.

Hydraulic properties

Most information on the hydraulic properties of the Omaka River Aquifer relates to the shallow aquifer layer. This is because there are more wells tapping the shallow layer compared to the deeper layer.

The water table of the unconfined shallow aquifer layer varies in response to fluctuations in Omaka River flow, which in turn affects well yield.

Low summer aquifer levels and the thin nature of the shallow aquifer layer can limit well productivity when demand is at its highest. As a result, more than one well is often needed by large irrigators to produce enough water due to the limited drawdown available.

The transmissivity of the shallow aquifer gravels varies in relation to flow in the adjoining river channel. Values may be as high as 3,000 to 4,000 m^2/day while river flows and well levels are high, but it is unlikely to exceed 500 m^2/day, and probably much less during the summer month of a dry year.

Values of gravel storage for the shallow layer are relatively high and range from 0.08 to 0.1, but their limited extent makes them poor water reservoirs over any extended period without regular recharge.

The hydraulic properties of the deeper aquifer layers aren't as well known as fewer wells and test measurements exist. However due to having the same parent material, it is fair to assume they behave in a similar manner to other Southern Valleys aquifers which have been extensively studied.

The permeability of deeper gravels is significantly lower due to their claybound nature. For instance the estimated transmissivity value for the deep well 3317 is 13 m^2/day, several orders of magnitude lower than for that of the shallower gravels.

A comprehensive test was carried out during May 1983 on well 1263 which taps water bearing layers screened at depths of 22.5 to 24 metres and from 32 to 35 metres, at Godfrey Road.

The test report (GCNZ -1983) described the source of groundwater at well 1263 as a leaky channel type aquifer with a transmissivity of 260 to 530 m^2/day. No drawdown effects were observed at neighbouring wells so the storage properties of the aquifer couldn't be measured. The report predicted that aquifer transmissivity would be significantly lower in late summer as groundwater levels fell by up to ten metres.

The second documented test involved well 2577 near Suttons Ford, and screened from a depth of 18 to 62 metres below the surface. However the main water bearing material occurred at 17 and 35 metres depth. A transmissivity value of 22 m^2/day was measured in May 1994 which is also relatively low.

Recharge and flow patterns

Omaka River flow is the dominating influence on local groundwater (Fig. 31.8). It provides direct recharge to shallow groundwater, and indirect recharge to deeper layers. However flood flows are necessary to force recharge water downwards through the intermediary gravels separating the aquifers. Shallow groundwater does not get transmitted to the deeper layer unless the middle layer is saturated first.

From Godfrey Road through to Woodbourne, the shallow and deep aquifer layers join together to become a single, deeper aquifer. The most rapid drainage of river water occurs in this reach where the layers are converging. River losses in this reach reflect the thickening of the gravel fan deposited by the Omaka River, and the disappearance of the aquitard separating the layers. Faulting may also contribute to the losses of surfacewater.

The way in which river water interacts with the shallow and deep groundwater layers was concisely expressed by the 1994 PDP report: "*River seepage into the deeper layer depends on how far down the valley Omaka River flow extends. When river flow is high, it extends far enough down the valley to enter a zone of increased seepage into the deeper layer. When river channel flow is low, surface flow doesn't extend far enough down the valley to reach the zone of increased seepage loss and the deeper aquifer water levels fall. Within the zone of increased river seepage the vertical conductance out of the river bed will be greatest during periods of high river flow, and will fall during periods of low river flow.*" (Fig. 31.9)

The exact volume of recharge for any given flow cannot be accurately predicted. A close relationship exists between the extent of the Omaka River wetted front and Omaka River stage at Tyntesfield Gorge (Fig. 31.10). However a subdued and delayed response in deep groundwater at well 1000, is a result of flow needing to saturate the total thickness of gravels.

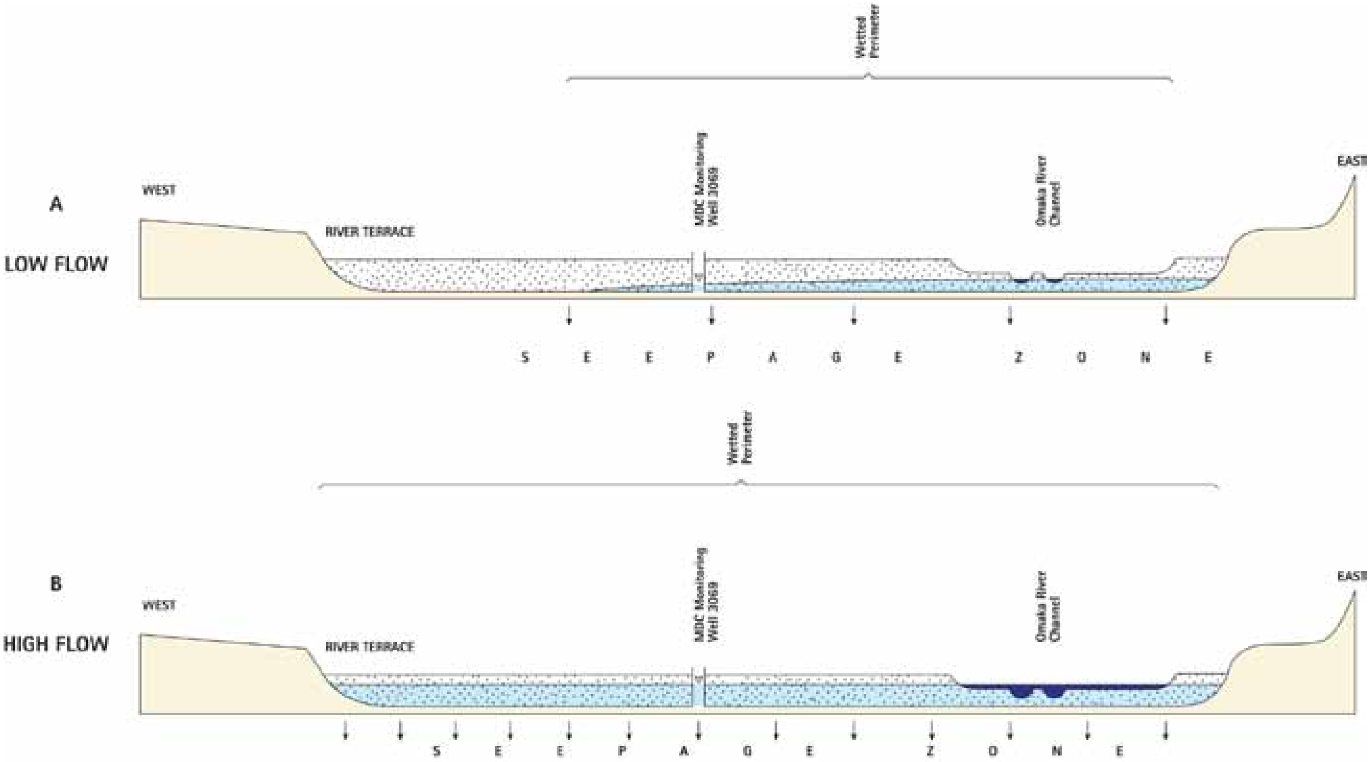

Figure 31.8: Shallow Aquifer interaction with Omaka River

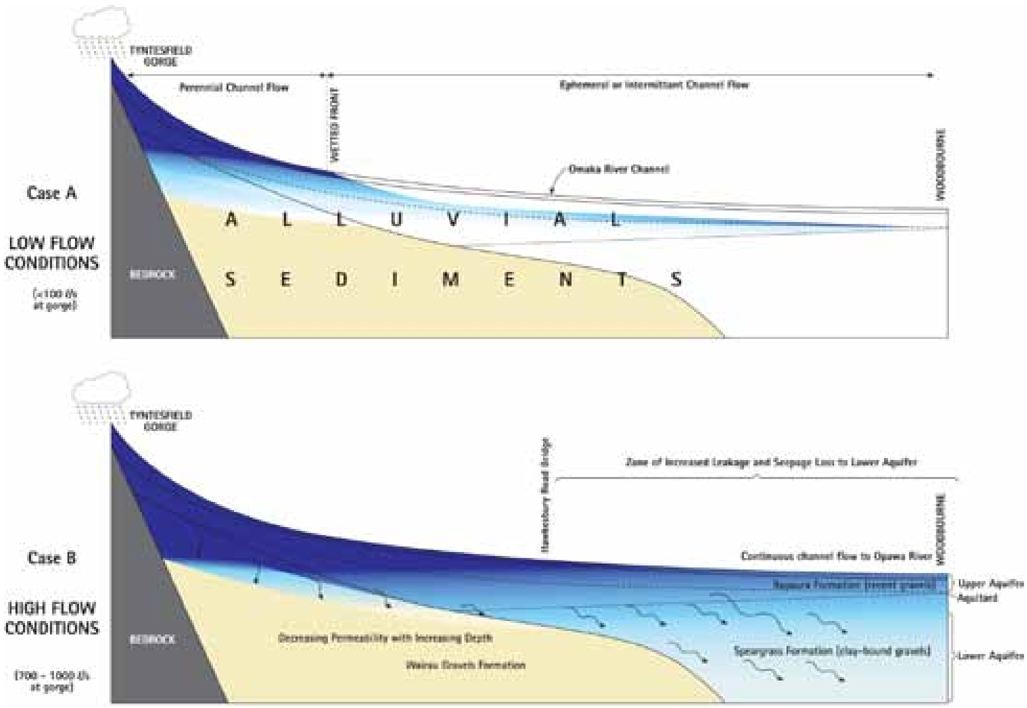

Figure 31.9: Omaka River and aquifer interaction conceptual model

In drier conditions deeper groundwater levels have fallen, while the water levels in the shallow layer have remained relatively constant due to the buffering influence of the hydraulically connected Omaka River (Fig. 31.13)

Flow records from well 1000 in the deeper layer show there is a large variation in groundwater levels over time. In contrast, there are much smaller fluctuations in groundwater levels at well 3069 in the shallow layer, which reflects the moderating influence of the hydraulically connected Omaka River (Fig. 31.14). Fluctuations in the seasonal shape of the hydrograph are characterised by a fall in levels of up to ten metres due to natural summer drainage, followed by a rise coinciding with the arrival of winter recharge once the Omaka River channel extends to the sea. The summer drainage cycle reflects the disconnection from the Omaka River recharge source and this natural phenomenon has been evident for many decades. This is normal behaviour for alluvial aquifers, but it is unusual that levels fluctuate so much and within such a well defined range, which points to an impermeable layer preventing deeper drainage.

The maximum level is controlled by river stage while the minimum level is controlled by the appearance of less permeable material at the base of the aquifer.

A similar cycle occurs elsewhere near Godfrey Road at well 1087, and Woodbourne wells 0661 and 0662; showing that a larger geological formation controls the behaviour of groundwater over the wider Woodbourne area.

During normal winter or spring conditions when the catchment is saturated and intermediary layers are wetted up, flows in excess of 700 l/s at Tyntesfield Gorge are sufficient to generate deep seepage. However, flows of 1,000 l/s or more are necessary under late summer conditions when the gravels separating the two aquifer layers are dry.

During the very dry conditions experienced during the 2000/01 drought, Omaka River flows of 1,000 l/s had a limited rejuvenating effect at well 1000 (Fig. 31.11). It is likely that the dry catchment conditions existing at this time soaked up any runoff and even by August deeper groundwater remained depleted.

Spatial differences in groundwater level have been used to map the direction of Omaka River Aquifer flow. These involved a series of water level surveys carried out by the MDC during the 1990s.

Under relatively wet catchment conditions groundwater in the shallow aquifer layer at Hawkesbury Road is around 10-15 metres higher than in the underlying deeper aquifer, reducing to 5 metres near Godfrey Road, before merging further east (Fig. 31.12).

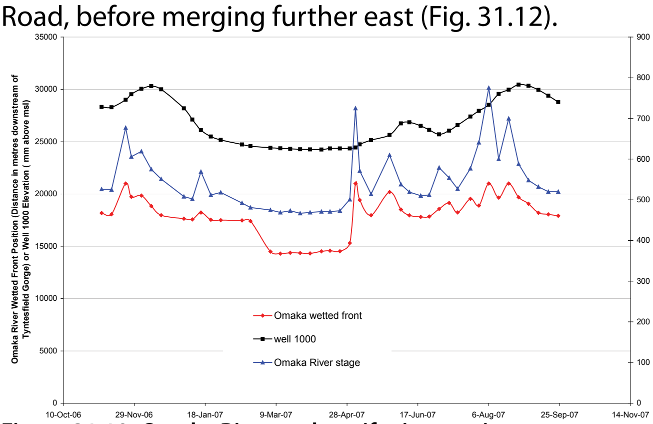

Figure 31.10: Omaka River and aquifer interaction

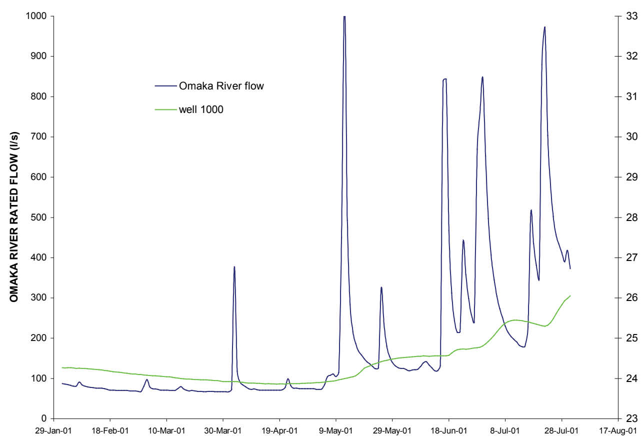

Figure 31.11: Surface and groundwater interaction in dry conditions

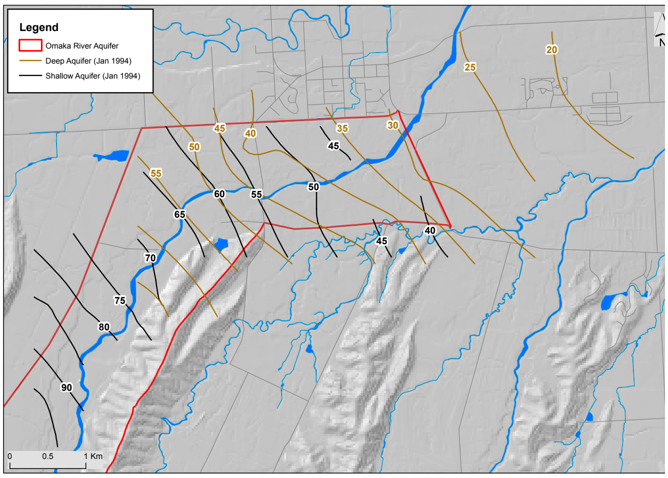

Figure 31.12: Aquifer water table under wet summer conditions

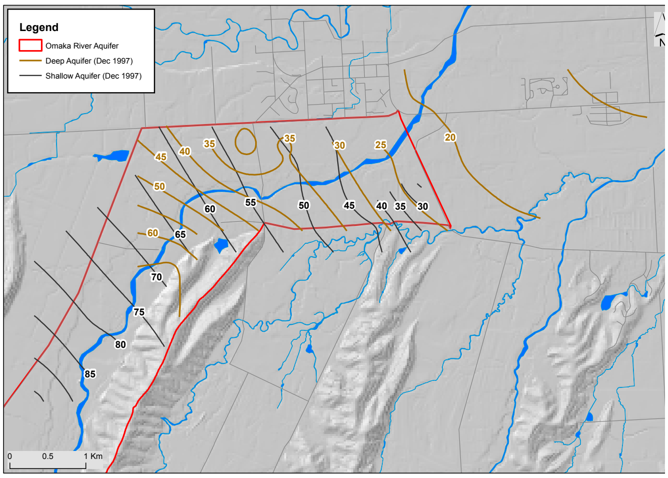

Figure 31.13: Aquifer water table under dry summer conditions

Groundwater chemistry

Until recently the emphasis in this catchment was on the physical aspects of groundwater hydrology and particularly its interaction with Omaka River flow. Chemistry was of limited value for improving understanding of hydrological processes because of the lack of contrast between Omaka River water and its related shallow groundwater.

As well depths have increased, significant differences in groundwater chemistry have been observed. The differences in groundwater chemistry are a result of successively slower rates of flow and more chemically evolved waters with increasing depth.

Shallow layer water is chemically similar to the Omaka River water which recharges it, whereas deeper

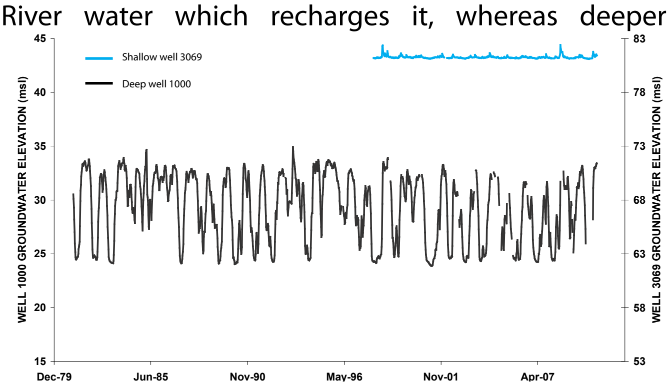

Figure 31.14: Aquifer water levels

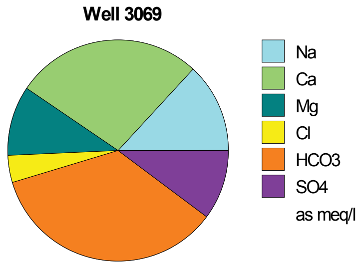

Figure 31.15: Well 3069 groundwater chemical composition

groundwater is more mineralised due to longer interaction with the aquifer forming gravels (Fig. 31.15 and Fig. 31.16). The two are of similar composition, with the exception of higher levels of nutrients. The presence of nutrients reflects the general use of fertilisers or presence of stock in this agricultural area. The similarity in water chemistry confirms that shallow groundwater originates from Omaka River water and that its residence time is likely to be short as its chemistry has not changed markedly.

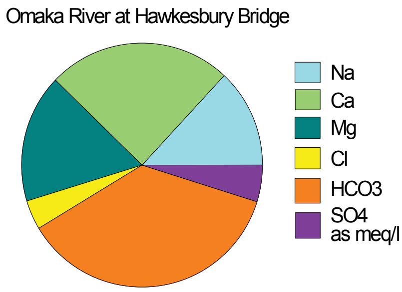

Figure 31.16: Omaka River water chemical composition

The composition of the deeper groundwater from well 3317, which sources most of its water from deeper strata of around 235 metres below the surface, is more evolved than the shallower groundwater (Fig. 31.17). The presence of sulphate however, shows that there is some residual influence from younger water.

Levels of nitrate-nitrogen in the shallow groundwater are a good indicator of the age and influence of landuse (Fig. 31.18). Peak values in well 3069 are ten times background concentrations and coincide with storms which leach nutrients to groundwater. The high values return to low levels presumably due to the flushing and diluting effect of Omaka River water.

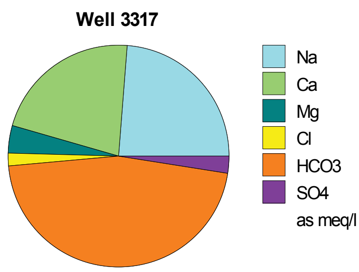

Figure 31.17: Well 3317 groundwater chemical composition

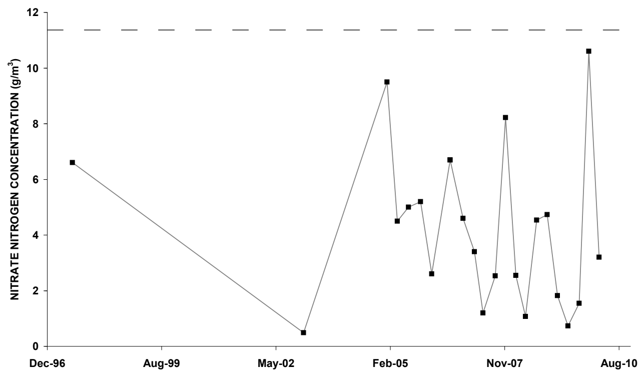

Figure 31.18: Shallow groundwater Nitrate-Nitrogen variation

Deep groundwater from well 3317 is isolated from agricultural processes and subject to natural degradation processes like denitrification. As a result nitrate-nitrogen levels are 300 times lower in well 3317 groundwater at 0.035 g/m^3. These significant differences in groundwater chemistry with well depth reflect the stratification of groundwater layers forming the Omaka River Aquifer.

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