Chapter 41: Linkwater Aquifer

Introduction

Linkwater is a low lying alluvial plain about five kilometres in length separating Okiwi Bay at the head of Queen Charlotte Sound, from the Mahakipawa Arm of Pelorus Sound (Fig. 41.1). Linkwater is approximately half way between Picton and Havelock. The maximum elevation of Queen Charlotte Drive in the Linkwater area is around 17 metres above sea level.

In the past it was thought that with annual average rainfall of 1,500 mm a year, crops in the Linkwater area were unlikely to require intensive irrigation in most summer seasons. While there has always been some irrigation of crops and pasture in the Linkwater area, water demand increased significantly following the 1998 and 2001 summer droughts.

Most water in the area is sourced from groundwater due to the lack of perennial surface flows.

The first systematic investigation of groundwater resources at Linkwater was commissioned by the MDC in early 2006 (GNS – 2009). This baseline study included a review of the local geology, but the focus was on the application of environmental isotopes and hydrochemistry to understand aquifer dynamics.

Due to the natural downwards tilting of the Marlborough Sounds to the north, creeks flowing north into the Linkwater area have more extensive catchments, wider valleys and higher flows than those flowing south. This determined the way aquifers were formed and are recharged (GNS Science - 2009).

Groundwater systems

Groundwater is a significant natural resource to the local community for drinking and agriculture. The Linkwater Aquifer describes the series of water bearing layers hosted by local alluvium.

Figure 41.1: Linkwater looking west

The Linkwater Aquifer is thought to be hosted by alluvium up to 100 metres deep and is recharged by leakage from local streams or direct infiltration of rainfall. The Linkwater Aquifer is unique amongst the Marlborough Sounds catchments, lacking a perennially flowing river and having two seawater coastal boundaries.

The alluvium overlies schist basement and is formed of sands, silts or clay-bound gravels eroded from local hills. The lack of continuity between geological strata, and the absence of well sorted gravel deposits means there is unlikely to be a broad, high yielding aquifer present. Notwithstanding this, significant groundwater resources do exist.

It is clear from well logs that water bearing layers can occur at any depth and their location is unpredictable. Well depths vary considerably from less than 10 metres to 77 metres below the surface.

Well yields also vary from high to low, reflecting the variable geology of the alluvium and seasonal fluctuations in aquifer recharge. For example, the capacity of shallow wells will diminish during summer as streams providing recharge recede.

Geology

There is a reasonably clear picture of the shallower strata beneath the Linkwater area based on drilling information for most areas. However there are few deep wells to show the depth to basement. The

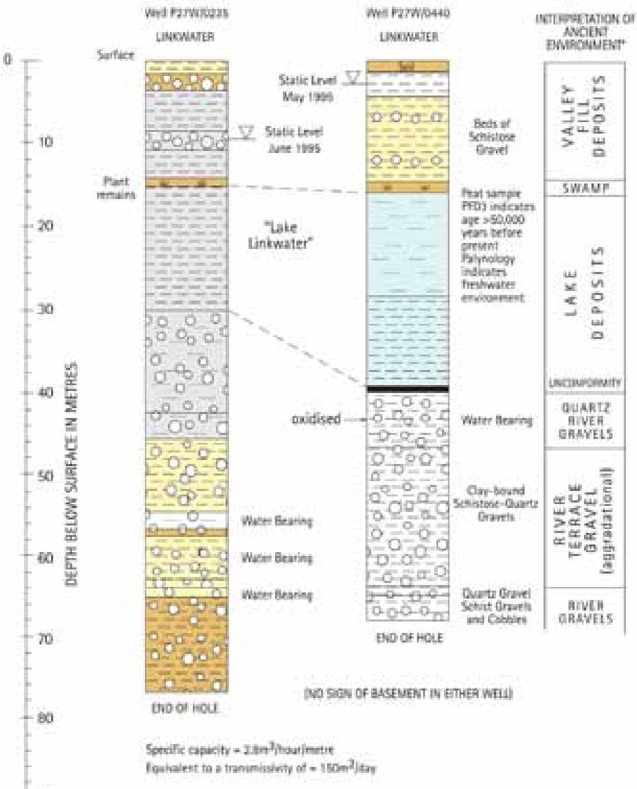

Figure 41.2: Linkwater geological cross sections

deepest well at 77 metres is well P27w/0235, sited southwest of Linkwater school. Well P27w/0235 is used to supply groundwater for irrigating dairy pasture and crops. Neither this well nor well P27w/0440 nearby intercepted schist basement (Fig. 41.2). This infers that the alluvium is at least 80 metres deep in this central area.

The width of the valley and the presence of clean, pebbly quartz gravel in the lower part of test well P27w/0440 indicates the historic presence of a reasonably large river. Prior to the flooding of the Marlborough Sounds by the sea, a river flowed south-westwards down Queen Charlotte Sound through Linkwater to join the Pelorus River. The Kenepuru River that drained the current day Kenepuru Sound also joined the Pelorus River at Havelock, before flowing down the Kaituna Valley and joining the Wairau River.

An ancient lake once existed under much of the Linkwater area (Fig. 41.3). The presence of the lake was identified by the occurrence of distinctive organic material and blue lake derived clay in the records of many wells. The lake was probably formed in a quiet depositional area away from the direct influence of ancient rivers. It could possibly have been caused by Cullen Creek damming drainage towards the west. Well logs show a layer of peat with wood of podocarp species at the top of the lake beds, indicating that the lake became completely infilled with mud and became a swamp. The peat layer is at or near present day sea-level. Samples of peat and wood from a depth of 16 metres in testbore P27w/0440 were radio-carbon dated to determine the age of the swamp and the minimum age of the lake. These results showed the material was deposited more than 50,000 years ago in a freshwater environment.

Figure 41.4: Re-emerging groundwater entering Cullen Creek

A number of the wells used to describe the local hydrogeology were drilled as part of a feasibility study by the Marlborough Harbour Board in 1977, to link Kenepuru Sound with Queen Charlotte Sound by a canal.

Recharge and flow patterns

As with most of the shallow riparian type aquifers in Marlborough, surface flow is connected to shallow groundwater.

Cullen Creek is the most significant surface waterway in the catchment and is associated with the most productive aquifers. Its fluvial action has sorted sediments and improved their permeability. Channel losses also represent the main source of recharge for nearby water bearing layers, to replace that which is withdrawn by pumping or natural drainage to the sea.

Cullen Creek is ephemeral for part of each year depending on seasonal rainfall. During this time all channel flow is lost to groundwater, although some emerges in the lower reaches as springs and returns flow to the lower reaches of Cullen Creek (Fig. 41.4) (GNS - 2009).

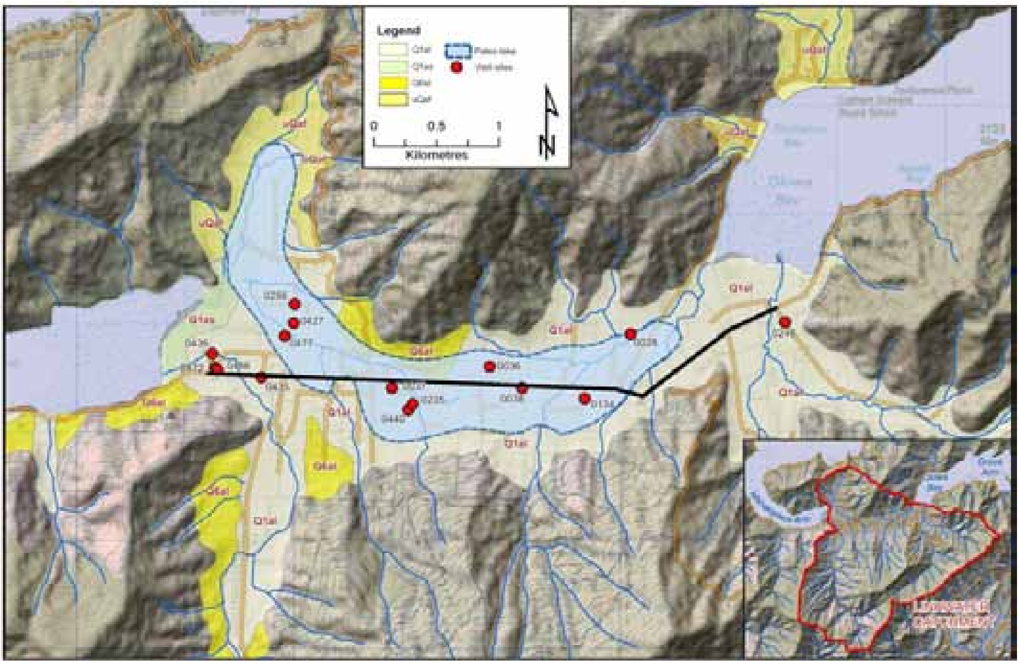

Figure 41.3: Lake Linkwater and present day wells

Groundwater flow mimics the surface and probably the basement topography, moving from elevated areas towards sea-level. A groundwater divide exists near Linkwater School with groundwater likely to flow east towards Queen Charlotte Sound, and the remainder flowing west to the head of Mahakipawa Arm.

Groundwater from wells distant from Cullen Creek is mainly recharged by rainfall.

Figure 41.5: Water well drilling rig prospecting for gold at Cullensville 1924 (Marlborough Historical Society)

The history of the underground phase of gold mining at Cullensville is very pertinent to groundwater hydrology in the area. The first phase of gold mining took place in the 19th century and continued off and on until about 1940 (Fig. 41.5).

Groundwater originating from schist basement rock caused significant problems for historic underground gold mining operations that took place around Cullen Creek. This basement rock sourced groundwater is likely to still contribute to aquifer recharge. However it is unlikely that sufficient quantities of groundwater occur in the schist bedrock for irrigation. Although it is fractured and jointed, the permeability of the schist is too low to store or transmit sufficient quantities of water.

Hydraulic properties

The most intensively studied area is the Cullen Creek catchment. Mineral exploration in the mid 1990s systematically drilled around 170 test wells across the Cullen Creek fan to assess the economic viability of placer gold deposits within the alluvium (Fig. 41.6).

As part of this investigation Royds Consulting prepared a hydrological assessment of the Cullen Creek sub-catchment and the feasibility of an opencast mining operation (Royds Consulting - 1995). The Royds report described the hydrogeology of the Cullen Creek area as that of: *"an unconfined aquifer receiving recharge from direct infiltration of rainfall, seepage from Cullen Creek and old mine shafts"*.

They described the general direction of groundwater flow as northwards towards Kenepuru Sound, the same as surface drainage. According to the Royds report: *"extremely anisotropic, discontinuous layers of clay are common, including a semi-persistent 2 metre thick unit of clay commonly present at 22 metres depth"*.

Two aquifer tests were carried in 1995 to measure the hydraulic properties of local gravels in order to assess the dewatering required to keep any mining excavations dry. Average values of transmissivity and storativity derived from these tests were 520 m^2/day and 1.7×10^{-3} respectively. A large range in values was attributed to the heterogeneity and the flat plate like structure of the gravels forming the aquifer (Fig. 41.7). It is likely that aquifer transmissivity also varies in relation to flows in Cullen Creek. The test report concluded that the dominant boundary effect was the impact of the valley sides formed by the schist ranges, rather than recharge from Cullen Creek.

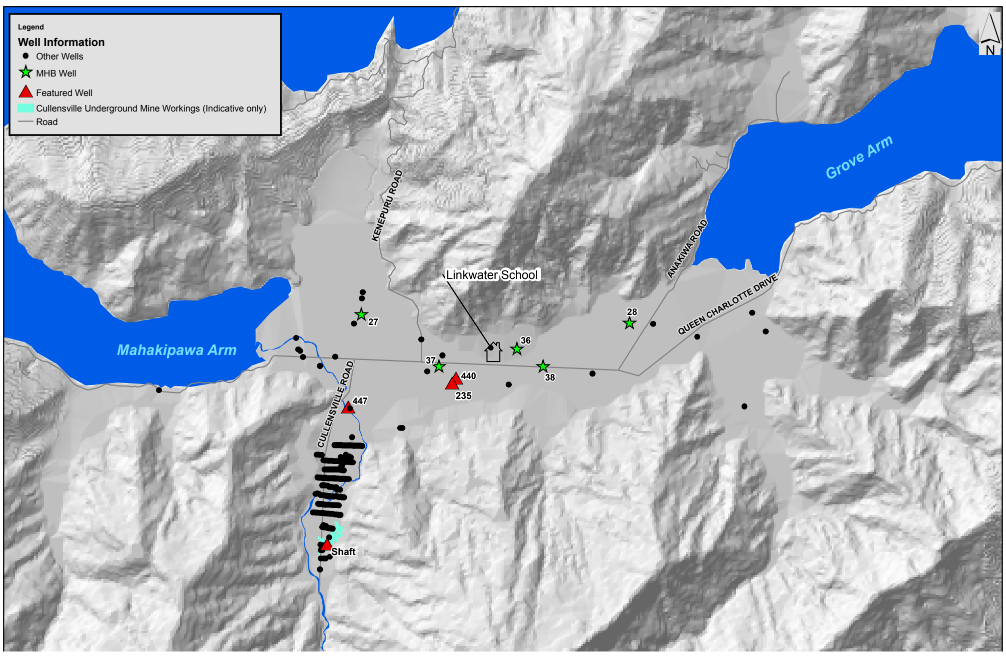

Figure 41.6: Linkwater well location

Figure 41.7: Typical Cullen Creek gravels

No aquifer test information is available from the Queen Charlotte Sound or eastern sector of Linkwater. Based on the drainage pattern it is likely that the aquifers beneath this part of Linkwater will be less permeable and lower yielding because of the lower energy streams which existed there compared to Cullen Creek.

Historic mine shafts dating from the 19th century onwards have modified the natural direction of groundwater flow in some areas. For example, a significant flow of groundwater emerges continuously from a vertical, disused mine shaft approximately 500 metres north of the information board at the historic Cullensville settlement. The old mine workings presumably provide a preferred pathway for groundwater, which in this case flows out at the surface and contributes to the natural surface flow of Cullen Creek (Fig. 41.8). Mine shaft water represents an important contribution to the baseflow of Cullen Creek under summer conditions. The 41 metre deep shaft was excavated between 1926 and 1928 (Fig. 41.9).

Figure 41.8: Groundwater flowing from Mahakipawa Goldfields Ltd mine shaft 2006.

Groundwater chemistry

There is a large variation in the age of groundwater in this aquifer. Residence times range from less than 3 years to 110 years. Groundwater age increases with well depth and the older, deeper groundwater is more mineralised due to natural water/rock interaction.

Most groundwaters are relatively dilute and unchanged chemically from their origin as stream or rainfall recharge water. Older and deeper groundwater from well P27w/0235 is however more evolved with correspondingly lower levels of dissolved oxygen and nutrients. There are some signs of land-use impacts on shallow groundwater quality of the type generally associated with intensive agriculture.

Groundwater from medium depth well P27w/0447 is dominated by recently recharged Cullen Creek water (Fig. 41.10). This water is dominated by calcium and bicarbonate which is typical of young groundwaters, and also an appreciable amount of sulphate, probably from surrounding landuses. The water from Cullen Creek is essentially the same chemically (Fig. 41.11). Deeper groundwater from well P27w/0235 has virtually no sulphate due to the natural degradation processes commonly associated with isolated aquifers and reducing conditions (Fig. 41.12). These same processes probably explain why magnesium has increased at the expense of calcium.

Figure 41.9: Mahakipawa Goldfields Ltd historic mineshaft headworks 1920s (Marlborough Historical Society)

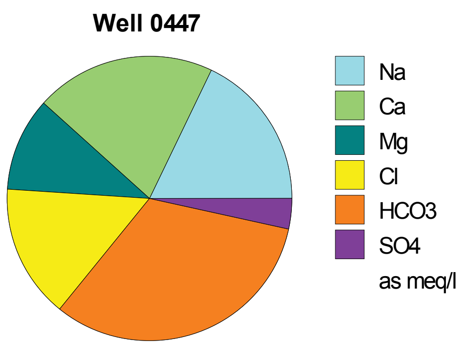

Figure 41.10: Well 0447 groundwater composition

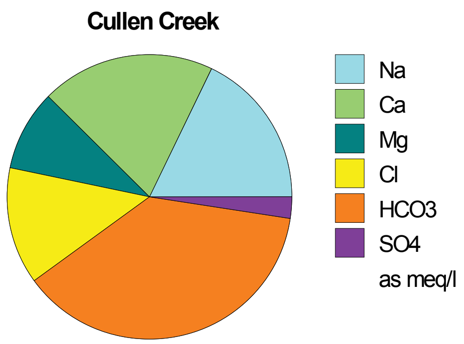

Figure 41.11: Cullen Creek groundwater composition

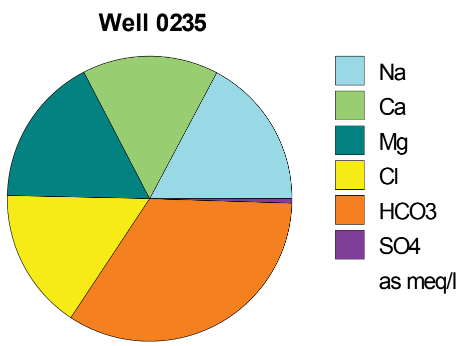

Figure 41.12: Well 0235 groundwater composition

References

Begg J.G. & Johnston, M.R. 2000. Geology of the Wellington Area. Institute of Geological and Nuclear Sciences Ltd, 1:250,000 scale geological map

Craw, D., Anderson, L., Rieser, U. and Waters, J. 2007. Drainage reorientation in Marlborough Sounds, New Zealand, during the Last Interglacial. New Zealand Journal of Geology and Geophysics 2007, Vol. 50: 13-20

Johnston, M. 1993. Gold In A Tin Dish, Volume Two, The History of the Eastern Marlborough Goldfields

Modriniak, N. and Marsden, E. 1938. Experiments in geophysical survey in New Zealand

Morgenstern, U. Brown, L.J. Daughney, C. Begg, J. and Davidson P. 2009. Linkwater catchment groundwater residence time, flow pattern, and hydrochemistry trends, GNS Science Report 2009/08, May 2009

Mortimer, N., and Wopereis, P. 1997. Change in direction of the Pelorus River, Marlborough, New Zealand: evidence from composition of Quaternary gravels. New Zealand Journal of Geology and Geophysics 1997, Vol. 40: 307-313

Royds Consulting. 1995. L & M Mining Ltd Theoretical Groundwater Inflow to the Proposed Cullen Creek Open Cast Mine Preliminary Report, prepared for L & M Mining Ltd

Chapter 42: Tuamarina River Valley And Picton

Introduction

The Tuamarina River is a tributary of the Wairau River which flows south from its origins on the slopes of Mt. Freeth, near Picton (Fig. 42.1). The valley that contains the Tuamarina River is also known as the Waitohi Valley.

Geological subsidence of the Marlborough Sounds has reduced the slope of the Tuamarina River channel and resulted in the creation of the Para Wetland (Fig. 42.2).

The surrounding hills are formed of a mix of schist or greywacke basement rock, except around the Elevation where marine siltstones and coal measures occur. Alluvial gravels and sands that fill the base of the valleys have been deposited by the Tuamarina River over geological time. Aquifers are associated with the gravels and sands forming the valley floors. The depth and width of the aquifer forming alluvium varies depending on the proximity of the basement rock to the surface and the width of the valley.

Groundwater resources in the northern and middle reaches of the valley were first studied during the 1970s as part of investigations for the expansion of the Picton municipal water supply. Various investigations involving isotope tracers, geochemistry and pumping tests were used to understand the groundwater resource.

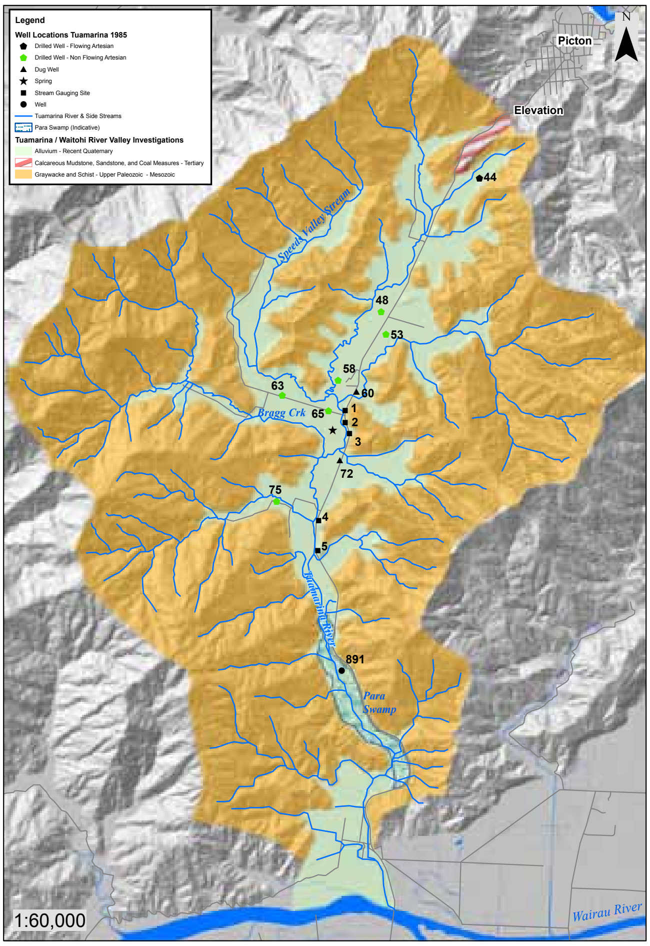

Figure 42.1: Tuamarina catchment boundary and geology

Figure 42.2: Tuamarina River and Para wetland looking south towards the Wairau Plain

Apart from the irrigation of the local golf course, traditionally there has been limited irrigation in the Tuamarina River Valley. Pasture irrigation wasn't required because of the relatively high rainfall in the area. Since the 2000/2001 drought however, a series of water permits have been granted to landowners, primarily for dairy pasture irrigation.

The Picton municipal water supply well-field at Speeds Road is the largest user of Tuamarina River Valley groundwater. The municipal supply was established in the early 1970s by the Picton Borough Council. The well-field is a supplementary source of water prior to Christmas. When the Picton water supply dams empty as summer progresses, the Speeds Road well-field becomes the primary source of public water supply for Picton residents.

Groundwater systems

Picton

While groundwater exists in the Picton area, to our knowledge it has never been found in sufficient quantities to warrant a commercial supply. There doesn't appear to be any reports documenting groundwater resources at Picton, or historic investigations.

In the early 1970s, Picton's water storage reservoirs were established in Essons Valley. The lack of potential aquifers in the local area led to exploration in the Waitohi/Tuamarina River Valley to the south, and ultimately the development of the present day well field at Speeds Road.

A review of the well logs from the Picton area suggests the area is underlain by alluvium, varying in thickness from 10 to 30 metres, overlying weathered bedrock. The alluvium is comprised of terrestrially derived yellow clay-bound gravels, and marine clays, timber or shells.

Much of what we know about groundwater beneath Picton is based on geotechnical investigation bores, rather than wells drilled specifically to pump