MARLBOROUGH DISTRICT COUNCIL

Spring-Autumn 2012/13 Taylor River Gauging Surveys Report

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Executive Summary

A series of monthly Taylor River surveys were conducted by the MDC between September 2012 and April 2013 to measure channel flow and origin of the water.

The base flow of Blenheim springs and the Taylor River is maintained by groundwater.

Taylor River baseflow during the rainless period from the 7th February to the 17th March 2013 was measured at 1.1m^3/second.

The 15th March 2013 gauging survey showed most baseflow originates from the Wairau Aquifer with only about 20% coming from the Southern Valleys catchments.

80-90% of Taylor River baseflow comes from groundwater fed springs underlying northern Blenheim including: Fulton Creek, Murphys Creek and Waterlea Creek; with a lesser contribution from diffuse flow through the channel bed.

During these rainless dry conditions the majority of Doctors Creek flow also originated from groundwater storage draining the Woodbourne & Southern Valleys areas as opposed to recent runoff.

A significant component of Taylor River flow was unaccounted for by tributary flow in the surveys and it was assumed to represent groundwater entering through the bed of the channel as there would have been little runoff at the time.

This mechanism is consistent with the findings of previous stream bed conductance studies of the Blenheim urban springs & Spring Creek catchment by MDC.

Groundwater is hydraulically linked to springs throughout Blenheim. In western areas of Blenheim (Springlands) the only factor isolating surface water from groundwater are fine sediments lining the channel bed.

Further east the aquifer becomes confined and the Taylor/Lower Opawa River systems gain flow from upwards inputs of pressurised groundwater.

Groundwater and surface water are effectively a single water body and taking from one is likely to affect the flow or quality of the other. For instance Municipal supply well field abstraction is likely to induce water from Murphys Creek at high pumping rates.

Contents

1. Introduction

Public awareness and expectations of Blenheim urban water resources are evolving. They are highly visible and shape the lives of many thousands of people every day. While we know very little about them hydrogically speaking, MDC have to plan for their future and filling gaps in our science knowledge is a priority.

MDC needed to know the natural low flow or what is commonly referred to as baseflow component of the Taylor River for a number of reasons. Firstly, as part of the review of district freshwater allocation policy, low flow thresholds on groundwater fed springs were an option MDC was considering for managing upstream groundwater takes, and a requirement of central government's national policy statement.

Secondly, distinguishing between baseflow and quickflow was recognised as central to identifying the effects of urbanisation on the water quality of the Taylor River and its drivers. One application of this knowledge is managing stormwater runoff in the future.

The final reason is to improve understanding of the general hydrological processes of the Blenheim area and the interaction between surface water and groundwater. Blenheim overlies a hydrological intersection and receives water from multiple directions and sources. However the mechanisms involved haven't received much attention or been reported on to date.

The new insights into Blenheim urban hydrology uncovered here form part of the more comprehensive MDC Taylor River catchment project.

2. Background

Taylor River baseflow is predominantly supplied by Wairau Aquifer water arriving from the north-west with a lesser contribution from the Southern Valleys catchments which include the Omaka River, Fairhall River, Doctors Creek and Taylor River (Figure 1). The Taylor River catchment contributes most of the high flood flows with local rainfall runoff from the surrounding land adding the quickest flow as it has the shortest route to travel.

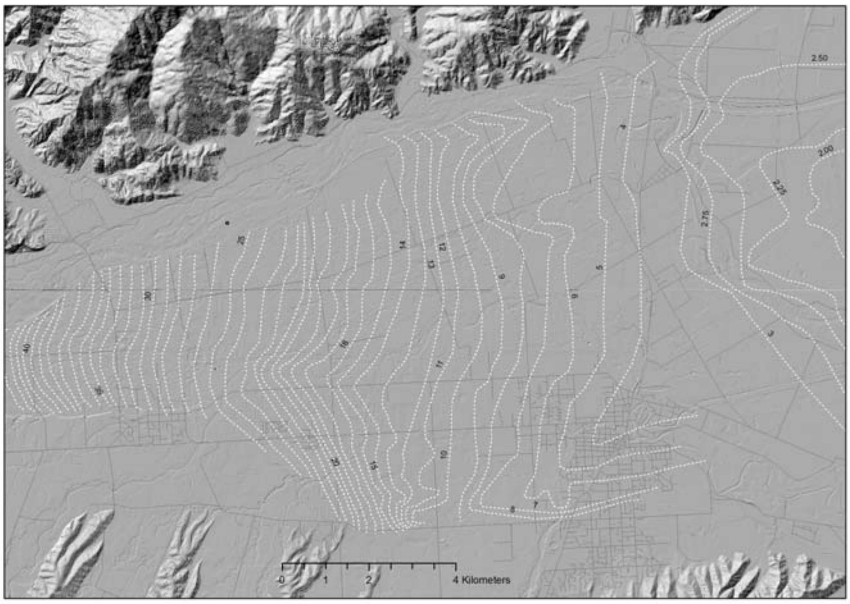

Figure 1 : View Of Central Wairau Plain Showing Contours of Groundwater Table Elevation For March 1978 (m. above msl). Blenheim is located bottom right

The direction of groundwater flow depends on the slope of the water table surface in unconfined areas of the Wairau Plain, but is more complicated in confined aquifers due to vertical pressure gradients. Groundwater flows at right angles to these contours and the curve around the Doctors Creek-Fairhall Co-op Drain area shows surface water is gaining at the expense of groundwater (Figure 2).

Figure 2 is a close-up of the Blenheim area of interest with the colours showing the variation in land surface elevation with lower lying areas in brown or yellow coinciding with springs where the water table intersects the land surface.

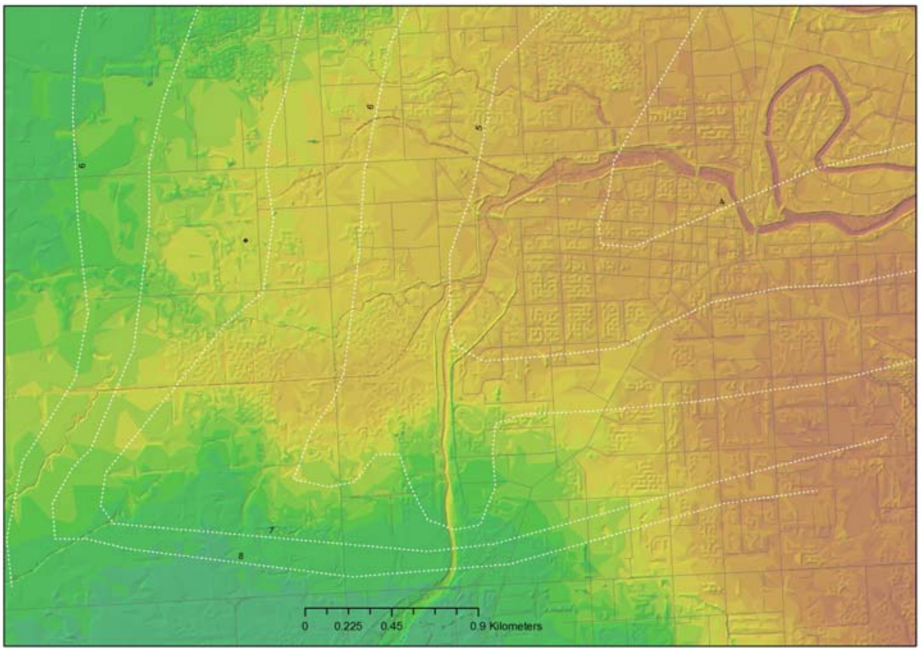

Figure 2 : Close-up of Water Table Contours Superimposed On Land Surface Topography For Taylor River Study Area

3. Methodology

Taylor River baseflow had previously been estimated by MDC staff at 1.2 m^3/s as part of the aquifer limits and safe yield report 2012. This figure was calculated based on water table slope, aquifer width and transmissivity to derive the throughflow rate of groundwater.

The opportunity arose to directly measure the spring baseflow component in late summer/early autumn 2013 under relatively dry conditions when there had been no rain for 40 days in a row at Blenheim (Figure 3). This meant that Taylor River flow and that of the contributing springs weren't affected by quickflow meaning the baseflow could be isolated and measured precisely.

Leading up to this dry period, MDC measured the flow of the Taylor River at Hutcheson Street and its main tributaries at monthly intervals to observe the changes in the relative composition of water as flows receded. Baseflow defines a class of water that while relatively steady does vary as groundwater levels rise and fall.

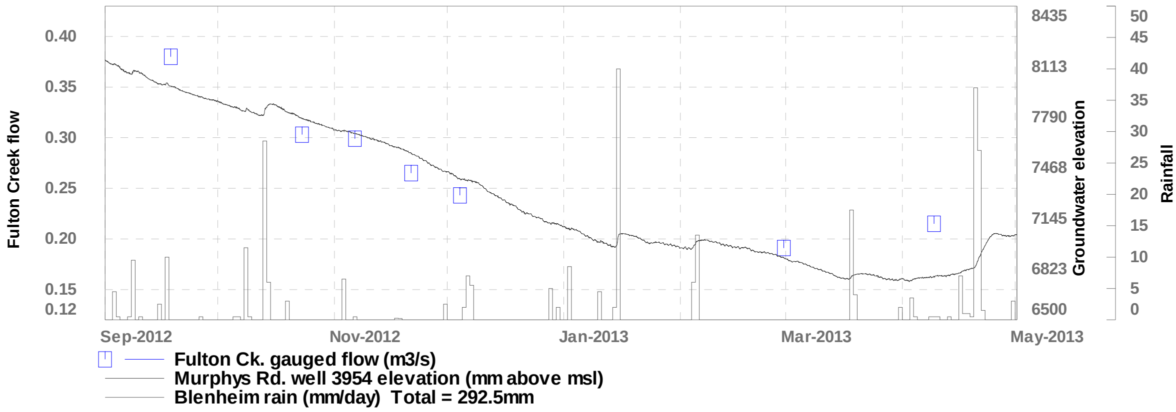

Figure 3 : Fulton Creek Flow Versus Rainfall And Groundwater Elevation Spring 2012-Autumn 2013

While Murphys Creek is a focus of this report, Fulton Creek flows were plotted in Figure 3 as more flow measurements existed for the critical 2012/13 period. Baseflow is the steady low flow component of a river hydrograph and here on the Wairau Plain it is supplied from groundwater draining the local alluvial gravel aquifers.

During the drier months here in Marlborough most river channel flow will consist of baseflow and conversely during winter or spring it will be a mix of baseflow and quickflow. Distinguishing between the 2 components is the first stage in identifying the drivers of changes in water quality. Groundwater fed springs have a much smaller range in flow because of the moderating effect of aquifer storage. This is why the urban springs of Blenheim don't flood.

Even if it hasn't rained for more than a month as was the case in early 2013, water stored mostly in the Wairau Aquifer, but with lesser contributions from the lower storage Southern Valleys aquifers largely maintain Taylor River channel flow through Blenheim.

Under these conditions the flow of the Taylor River slowly receded with time. Quickflow on the other hand is generated by rain falling directly on the built-up urban area and the surrounding land together with runoff from the hill catchment south of Blenheim. As the name suggests, it doesn't persist for long and shows up as short-term spikes in the river hydrograph.

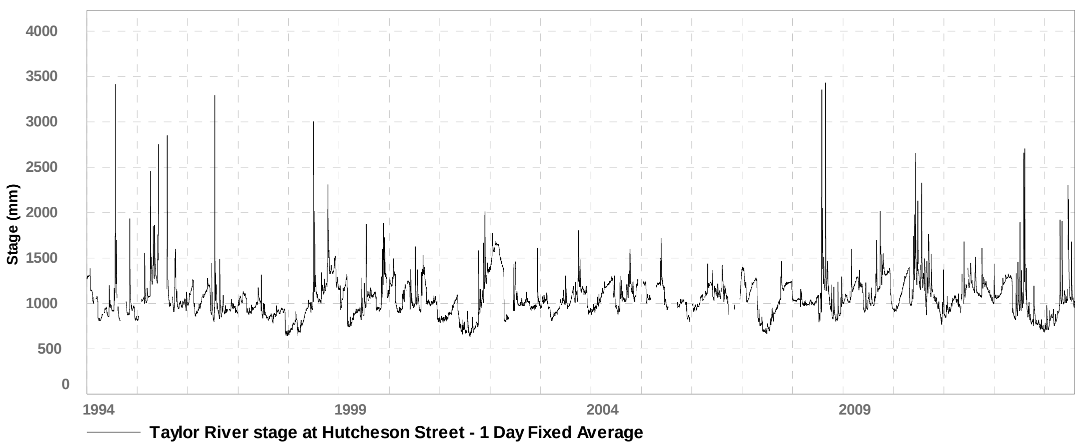

Figure 4 : Taylor River Stage at Hutcheson Street 1994-2013

A visual assessment of the time series of Taylor River stage since 1994 clearly shows the split between the minimum level representing baseflow and the spikes caused by floods or smaller rainfall events running off impermeable areas (Figure 4). Because the relationship between stage and channel flow is poor at this site due to tidal disturbances, the only way of accurately defining flow was by measuring it.

From September 2012 through to April 2013 MDC regularly gauged the flow of the Taylor River at Hutcheson Street bridge, Fulton Creek at Pollard Park and Doctors Creek upstream of the Taylor River confluence. The purpose was to measure the total Taylor River flow and define individual contributions from tributaries which in turn would identify any residual flow from runoff or groundwater inputs.

The flow of Murphys Creek and Waterlea Creek was no longer gauged on a weekly basis and their flow was interpolated for this project using the known relationship based on several hundreds of historical gaugings. However this introduced error into the residual flow and may explain why it varies.

In addition to this monthly series of gaugings, MDC carried out a more intensive survey on the 15 March 2013 when the river flow was low and there had been no recent rain. The extra measurements of flow were made at the following sites: Taylor River at High Street, Taylor River at Beaver Road, Murphys Creek at mini-railway bridge and Waterlea Creek between Parker Street and Nelson Street (Figure 5). These detailed measurements were intended to observe how flow increased in a particular reach and how much wasn't attributable to visible surface inputs.

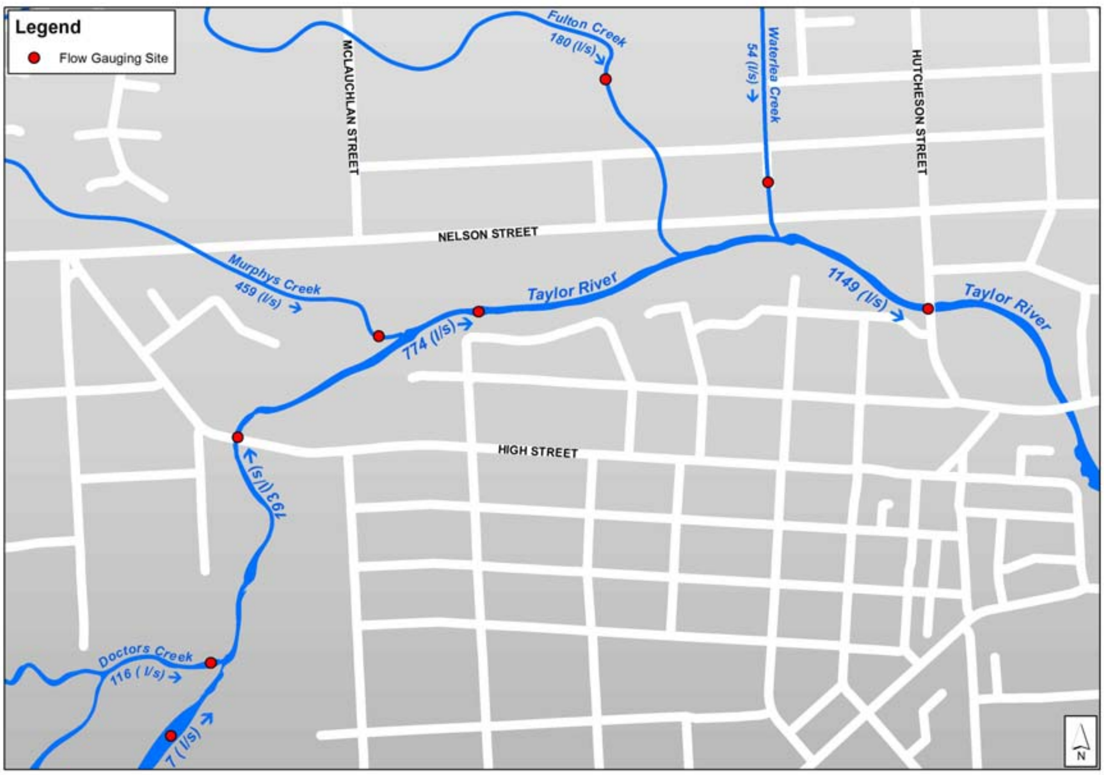

Figure 5 : 15 March 2013 MDC Flow Measurement Site Plan

4. Results and Discussion

The flows for the series of 7 gauging surveys from the 18th of September 2012 through to the 9th of April 2013 corresponded with a long declining trend in groundwater levels at the MDC Murphys Road well P28w/3954 where records date from 2002 (Figure 6). This well is located near the corner of Murphys Road and Old Renwick Road. During March/April 2013 groundwater levels were the lowest since records began.

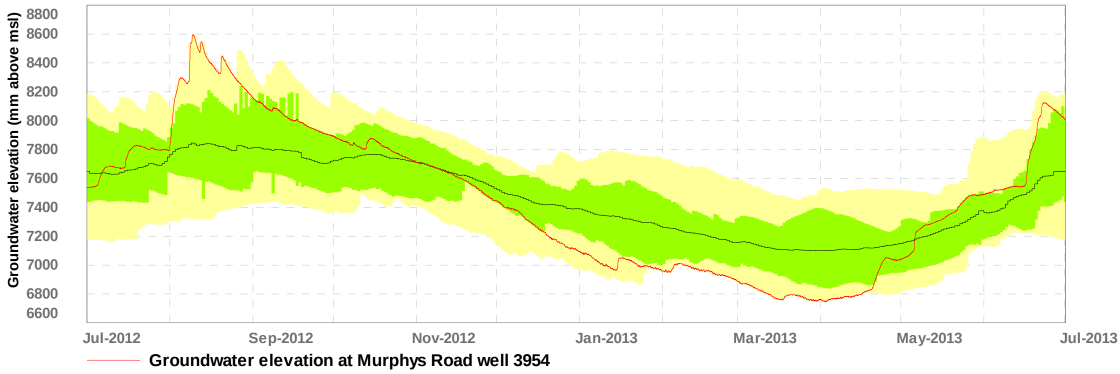

Figure 6 : MDC Murphys Road Well P28w/3954 Groundwater Elevation

The black line is the mean groundwater elevation in millimetres above mean sea level since 2002, and the red line shows the actual mean daily values from July 2012 through to July 2013. The green band represents 50% of observations for that day based on past record.

The baseflow of tributary springs and consequently the Taylor River is dependent on groundwater levels (Figure 7). It follows that during the rainless period from the 7th of February to the 17th March 2013, groundwater fed spring flows fell proportionately with declines in well levels.

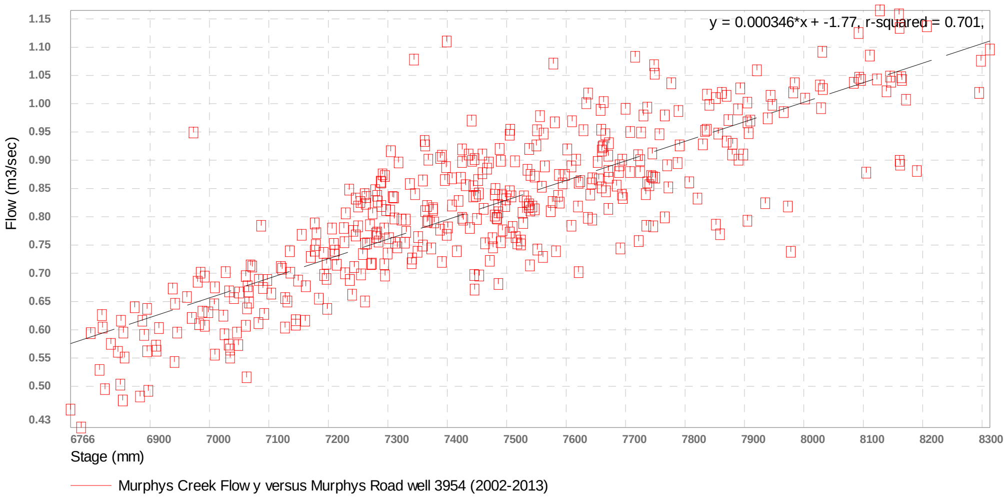

Figure 7 : Gauged Murphys Creek Flow Versus Mean Daily Groundwater Elevation At Murphys Road Well 3954 (2002-2013)

The flows for each monthly survey have been split according to their origin (Figure 8). Surface water was defined as the sum of Taylor River rated flow at Borough weir and Doctors Creek flow upstream of the Taylor confluence (blue). Winter or spring high flows in Doctors Creek are generated by hill catchment runoff, but the low flow of 106 l/s in early March 2013 will have a high groundwater content. This shows that the classes aren't exclusive.

Groundwater is defined as the combined flow of Waterlea Creek, Murphys Creek and Fulton Creek (green). But in reality these springs will also contain some rainfall runoff in addition to groundwater, especially in wetter months.

Flow not accounted for is termed residual and shaded grey (Figure 8). In wetter periods it will consist of rainfall runoff plus diffuse flow of groundwater to surfacewater. Under the low flow conditions experienced in early 2013 it must represent mostly groundwater seepage, but it is difficult to quantify these hidden sources.

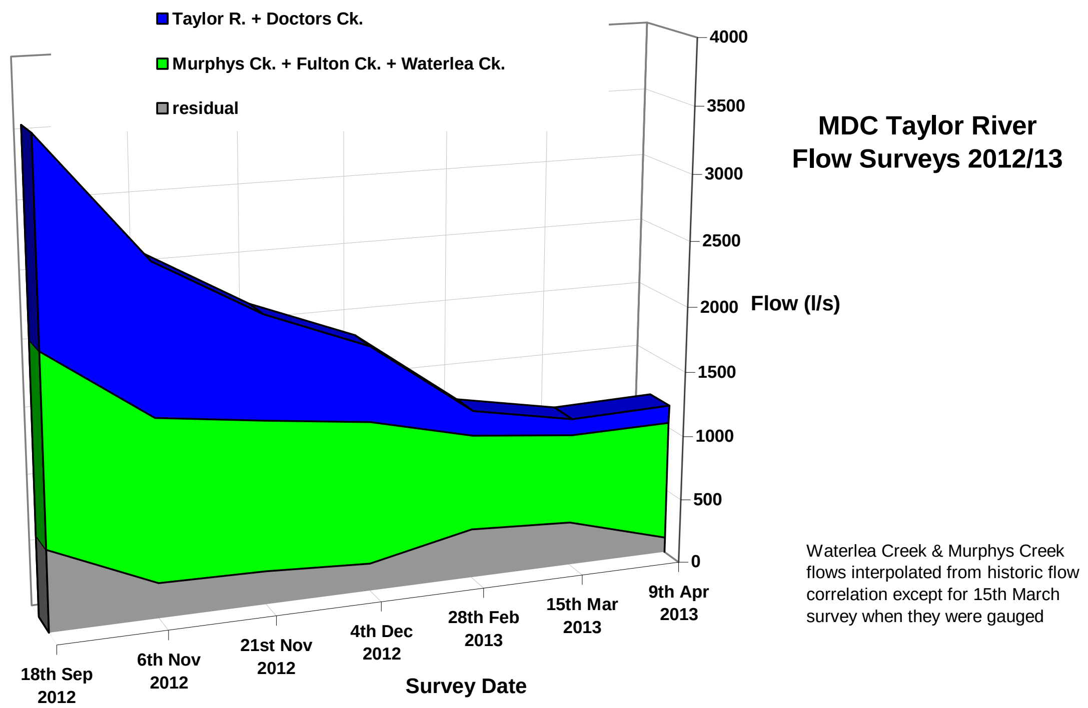

Figure 8 : Taylor River Flow At Hutcheson Street Source Components

The flow of the Taylor River at Hutcheson Street on the 15th of March was 1149 l/s. While this wasn't an exceptionally dry summer season in terms of rainfall or river flow, it coincided with the lowest recorded Spring Creek flow and the second lowest flow at Fulton Creek next to the 2001 summer drought.

Most of the Taylor River low flow measured on the 15th of March 2013 consisted of groundwater (Figure 8). The surface water contribution from Doctors Creek, excluding the 7 l/s of Taylor River flow, is also likely to be mainly groundwater.

This means that during the driest seasons the ecological functioning of the urban springs and the Blenheim public water supply relies on maintaining sufficient groundwater throughflow beneath Blenheim. This in turn is controlled by both natural factors such as the recharge rate and human influences like consented abstraction.

The cumulative gain in channel flow for the 15 March survey starting from just upstream of where Doctors Creek joins the Taylor River through to Hutcheson Street is most sensitive to tributary inputs (Figure 9), although it also shows a significant fraction isn't accounted for by them.

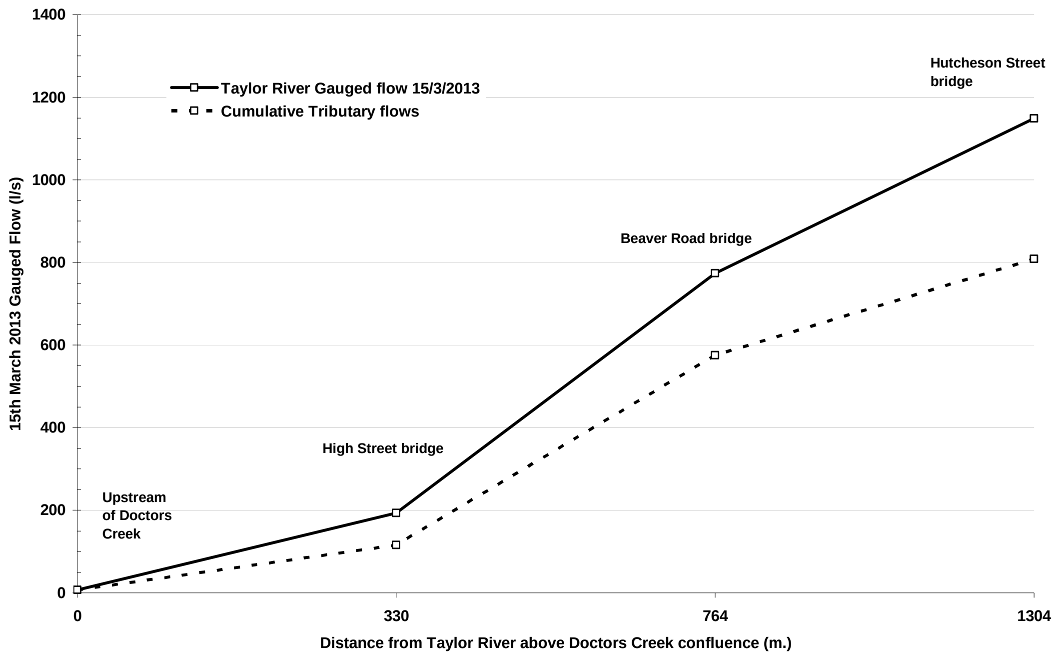

Figure 9 : Cumulative Taylor River And Tributary Flow Versus Channel Distance From Above Doctors Creek Confluence For 15 March 2013 MDC Survey

The gains in residual flow over a certain reach and their proportion of the gauged Taylor River channel flow show a reasonably steady increase with distance (Table 1). The rate of leakage per unit length of channel is even up to the end of the survey at Hutcheson Street. Because the degree of groundwater confinement increases in a downstream direction, the rate of leakage to the Taylor River further downstream is likely to decrease too.

Table 1 : Origin of Channel Flow Gains and Rates Of Influent Seepage

Distance from upstream of Taylor River with Doctors Creek (m.)	**Taylor River Reach**	**Flow gain (l/s)**	**Residual flow not accounted for by tributary sources (l/s)**	**Residual flow as (%) of gain**	**Average residual leakage (l/m)**
330	Upstream of Doctors Creek confluence down to High St. bridge	186	70	38	0.21
434	High St. bridge to Beaver Rd. bridge	581	122	21	0.28
540	Beaver Rd. bridge to Hutcheson St. bridge	375	141	38	0.26

5. Discussion

With the establishment of a state of the environment monitoring site for Murphys Creek at Nelson Street in 2009 to complement the existing set of seasonal groundwater quality measurements at the MDC Middle Renwick Road well field on the corner with Colemans Road, it was possible to compare the chemistry of the 2 water bodies for the first time. Figures 10 to 16 compare the variation in groundwater versus surface water of the following parameters: conductivity, nitrate-nitrogen, chloride, sulphate, pH, temperature and dissolved oxygen.

Whilst it is only a preliminary analysis at this stage, it appears the chemical and physical properties of groundwater and surface water are very similar implying they are closely related water bodies. Real time information is needed before any firm conclusions can be reached however.

Electrical conductivity is a measure of the total amount of dissolved solids or salts in the water and the value for Murphys Creek in particular is likely to depend on flow. Some weekly gaugings of Murphys Creek flow are available, but real time flow measurements are needed to properly weight conductivity values and the concentrations of other dissolved species MDC have analysed at the laboratory.

A preliminary assessment suggests conductivity of both surface water and groundwater vary seasonally with Murphys Creek flow, peaking in spring and reaching a minimum in autumn. It must be remembered that groundwater is taken from a high capacity well-field and that some samples may represent induced Murphys Creek water.

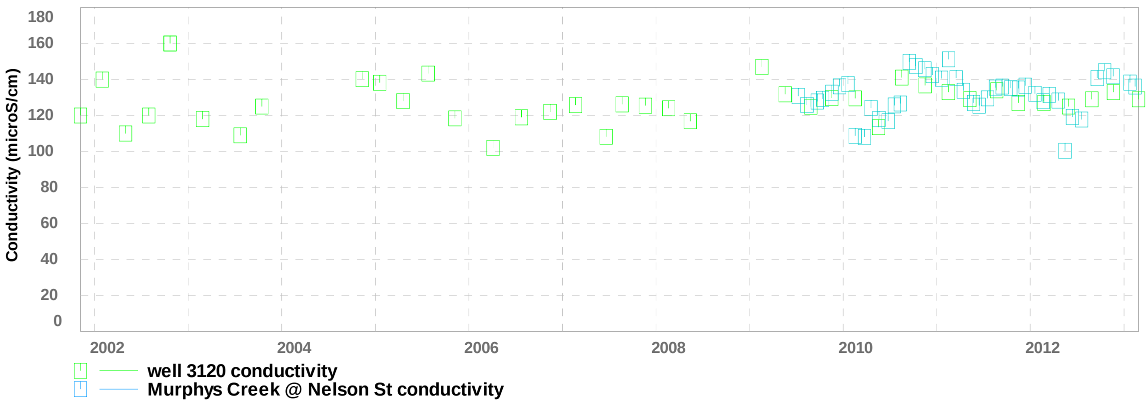

Figure 10 : Groundwater and Surface Water Conductivity

There is a complex variation in conductivity which requires more record to interpret but there are small overall differences between surface water and groundwater values based on the values available (Figure 10). This comparison is complicated by the fact that measurements weren't taken on the same time on the same day.

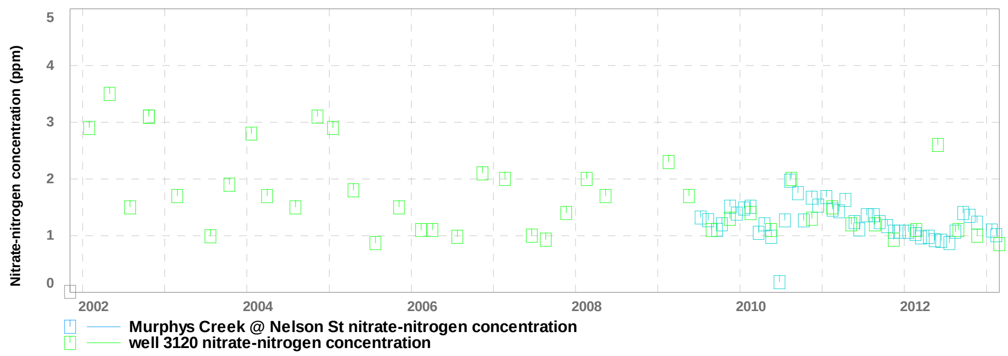

Figure 11 : Groundwater And Surface Water Nitrate-Nitrogen Concentration

Nitrate-nitrogen concentrations in groundwater have fallen since 2002 and mimic surface water levels. A longer length of record is needed to explain the causes of the variation (Figure 11).

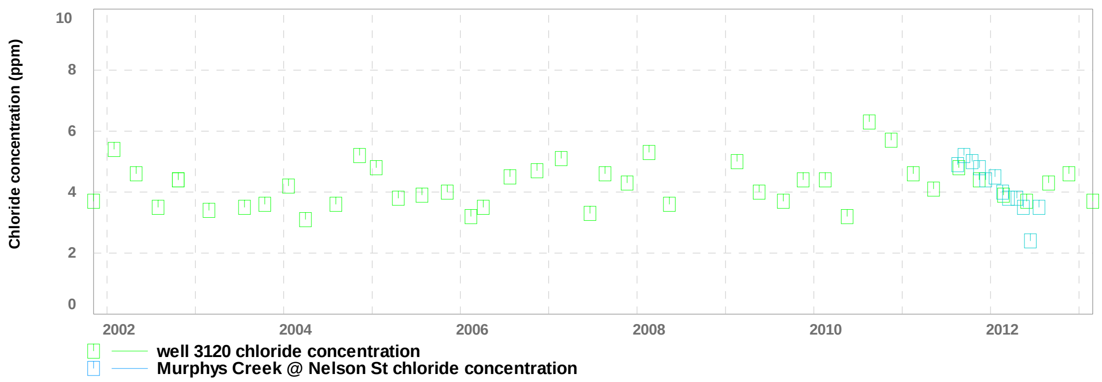

Figure 12 : Groundwater And Surface Water Chloride Concentration

There is insufficient overlapping record of chloride concentrations to make any firm conclusions at this stage but there appears to be a seasonal pattern on first inspection (Figure 12).

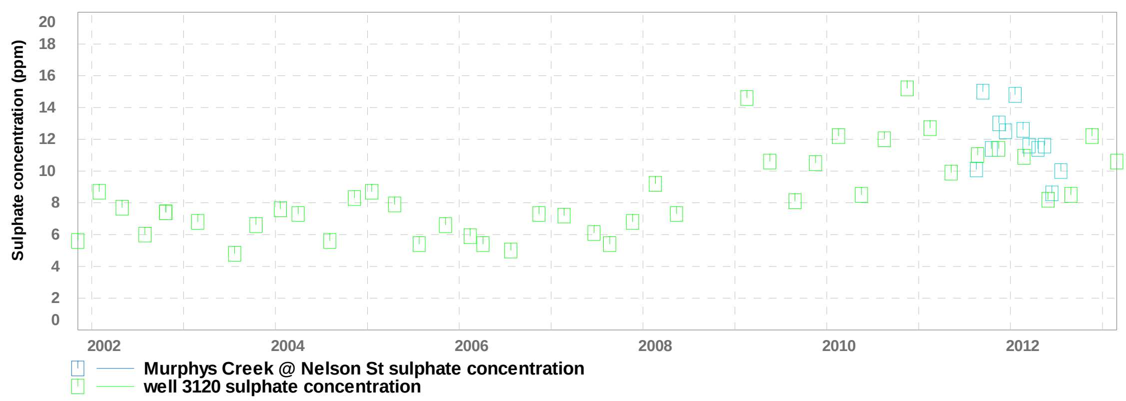

Figure 13 : Groundwater And Surface Water Sulphate Concentration

Sulphate values have risen over the period since groundwater samples were first taken in 2002 but the reasons aren't clear at this stage (Figure 12). There is clear rise in 2008 coinciding with higher rainfall and diluting power of runoff water.

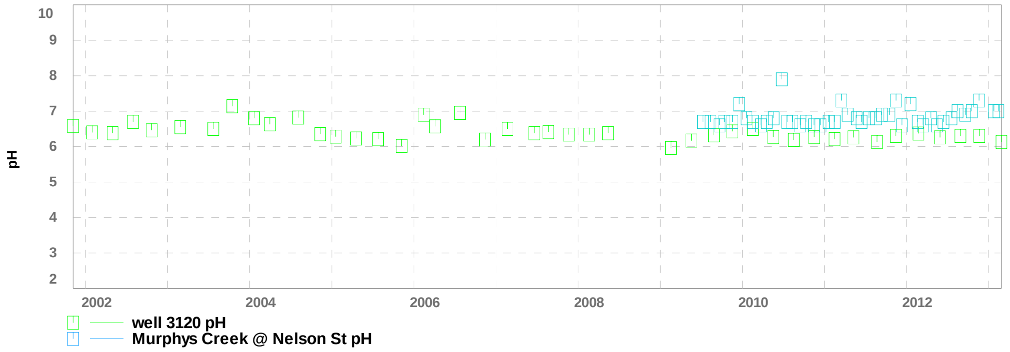

Figure 14 : Groundwater And Surface Water pH

The pH of surface water is slightly higher than that of groundwater which is consistent with the pattern seen in the Wairau River (Figure 14). What local runoff processes influence the pH of waters in the Blenheim area needs more work and record to define.

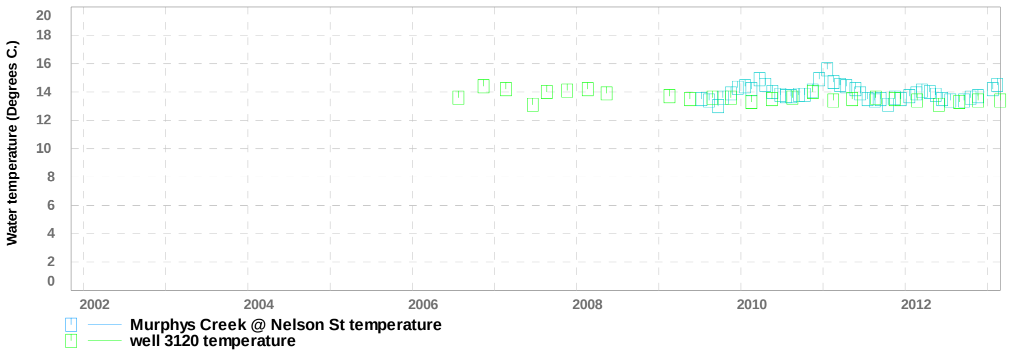

Figure 15 : Groundwater And Surface Water Temperature

As expected surface water has a slightly higher temperature than groundwater over summer, but there is little difference in winter or spring (Figure 15).

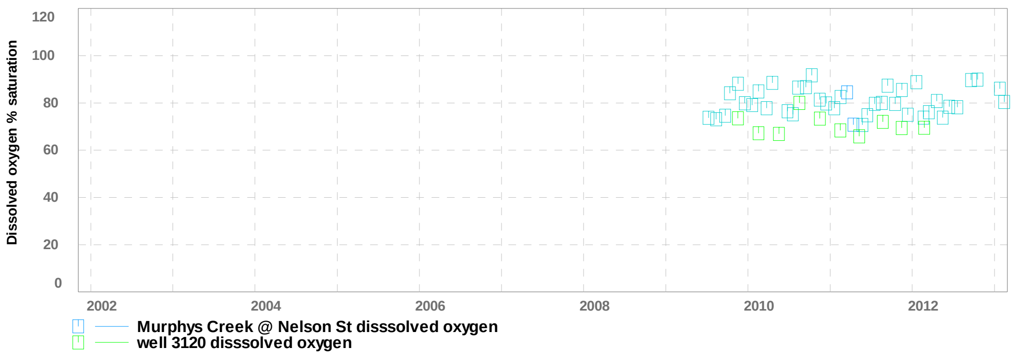

Figure 16 : Groundwater And Surface Water Dissolved Oxygen Relative To Saturation

As would be expected, surface water has a higher oxygen gas content than groundwater because it has been more exposed to the atmosphere (Figure 16).

6. Future Work

The next step is to develop a relationship between the flow of groundwater fed springs or the Taylor River and the dissolved solids content of surface or groundwater. This and the residence time of water will help identify the sensitivity of water quality to factors such as contributions of different catchment waters with varying mineralogy's versus the diluting effect of those flows.

A conceptual model of the Taylor River in Blenheim focusing on Murphys Creek sub-catchment introduces the flow components that dilute solutes and their origin (Figure 17). To quantify the components of the equation as part of the Taylor River catchment study, an automatic recorder will be installed at Nelson Street to provide continuous observations of Murphys Creek channel flow, water temperature and electrical conductivity.

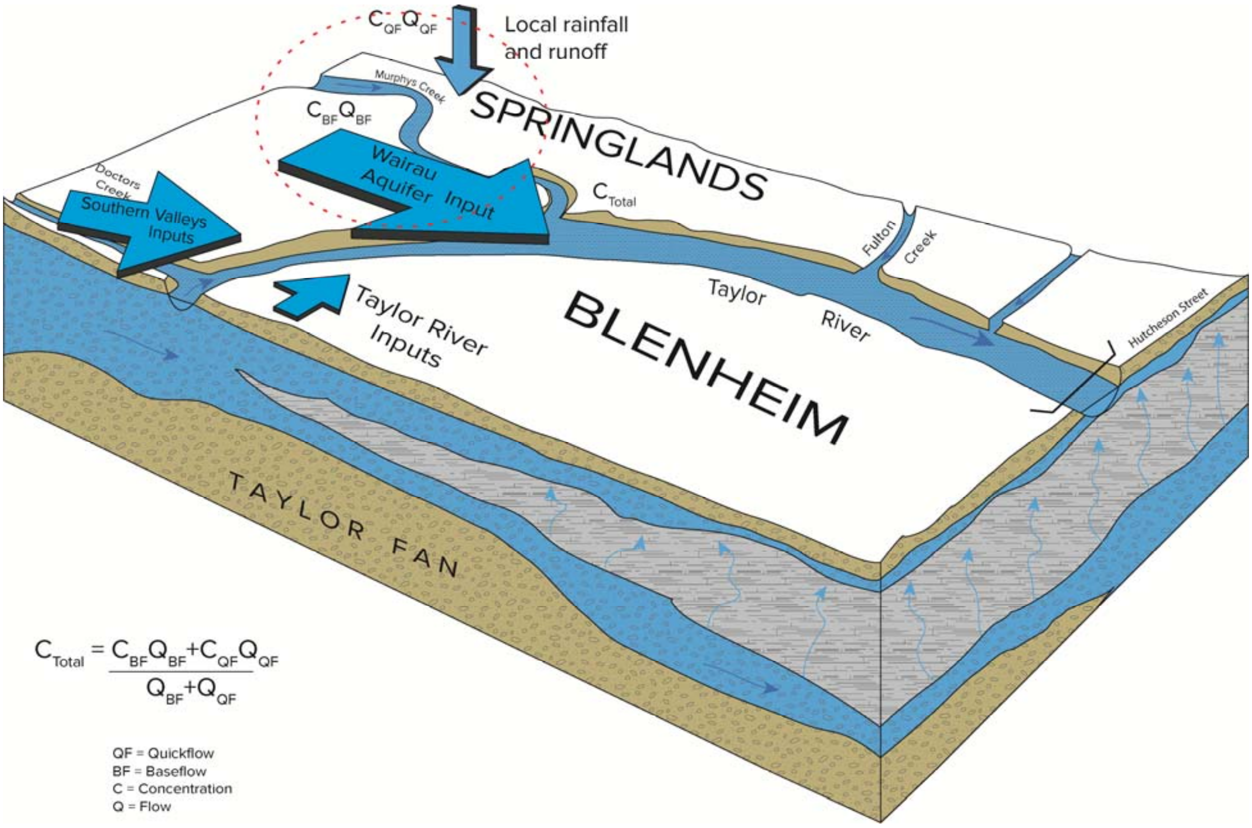

Figure 17 : Conceptual Model of The Relationship Between Blenheim Water Resource Solute Concentration And Flow