Chapter 19: Spring Creek

Introduction

Spring Creek or Awarua as it is known to local iwi, is the largest emergence of groundwater within the Wairau Plain. Year round, crystal clear water emerges as a series of springs near Hammerichs Road and increases in flow downstream until it joins the Wairau River just upstream of Spring Creek township (Fig. 19.1). The increase in flow downstream is a result of discrete spring inflow as well as upward seepage through the stream bed. By the time Spring Creek has reached Rapaura Road two kilometres downstream from the headwaters, its channel flow has grown significantly to around 1000 l/s at Stump Creek Lane. A series of spring fed tributaries also contribute to the overall flow along the length of Spring Creek. By the time Spring Creek reaches the Spring Creek township the flow has increased to an average of 4,000 l/s.

The physical catchment of Spring Creek is difficult to define because the surrounding land is so flat and watersheds are not well defined. However, the overall catchment area is approximately 1000 ha.

Since European settlement many of the springs and waterways of the Wairau Plain have been heavily modified to allow for the development of intensive agriculture. The main stem of Spring Creek has however remained in its natural course. Even the earliest maps of the mid 1860s show a large channel with its distinctive bend near the present day SH1 junction and hotel.

Origins of Spring Creek

Spring Creek is largely formed by upwelling groundwater emerging as springs (Fig. 19.2). It has a very small catchment and in the absence of rainfall all of the base flow of Spring Creek comes from groundwater. Water is induced to the surface by a combination of the change in slope of the aquifer water table relative to the land surface, and the changing structure of the geological formations forming the aquifer. In the western or upper reaches between Hammerichs Road and about Selmes Road, groundwater inflows to

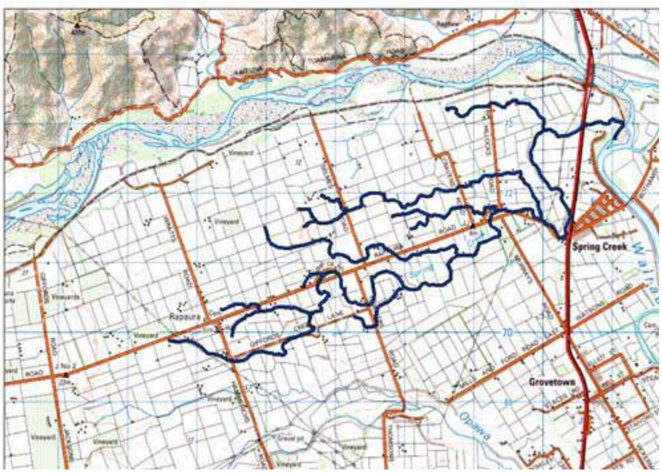

Figure 19.1: Spring Creek and tributaries

Figure 19.2: Spring Creek headwaters. The cone of fine sand in the middle of the photograph is caused by upwelling groundwater.

Spring Creek are topographically controlled. Springs emerge where the slope of the land surface falls more quickly than the underlying water table. Due to this natural flattening, groundwater intercepts the surface, particularly in low lying areas or depressions which are often symptomatic of old river channels. The slope of the land surface falls from around five metres per kilometre in the upper plains near Renwick to around two metres per kilometre in the mid-plains area; and less than one metre in the Lower Wairau area near the coast.

The second mechanism whereby Spring Creek gains flow from groundwater is caused by structural changes in aquifer geology and predominates in its mid to lower reaches. Fine grained clays and silts thicken in an easterly direction, to eventually form an extensive confining layer east of SH1. The fine grained clays of the confining layer are considerably less permeable than those of the aquifer and when groundwater intercepts this barrier, it is forced to the surface to form springs. Inland fine clays were formed in wetlands. They coalesce with marine clays east of SH1, and eventually thicken to form a confining layer up to 40 metres thick at depth below the Cloudy Bay coastline.

Diffuse leakage of groundwater upwards through the confining layer occurs because it is naturally porous, rather than being a complete barrier to flow. However flow rates are low unless there are cracks or fissures that allow groundwater to move along preferred pathways. This is a less efficient way of recharging Spring Creek channel flow compared to direct interception of groundwater or drainage. Rainfall also contributes a significant amount of recharge, but only for short periods.

The rate of increase in Spring Creek flow is variable along its channel. This reflects the relative dominance of each particular recharge process in a certain reach and the largest gains occur in the upper reaches. The flow in the main channel starts from nothing and steadily increases to more than 1000 l/s over a

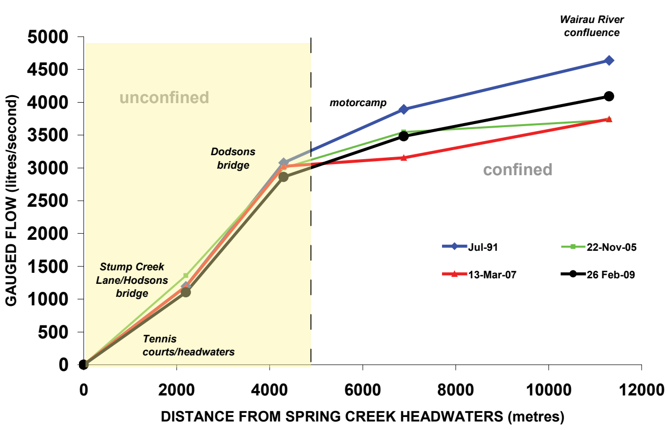

Figure 19.3: Spring Creek flow profiles

short distance. The channel gains less groundwater in its lower reaches because of the isolating effect of increased aquifer confinement (Fig. 19.3).

The rate of groundwater seeping into Spring Creek is measured by gaugings of flow at various points along the channel (Fig. 19.4). The flow in the tributaries varies greatly and reflects natural differences in the permeability of the underlying aquifer gravels and the streambed clogging sediments lining the base of the channel.

Seasonal variability in flow

Spring Creek flow reflects seasonal fluctuations of the water level in the underlying aquifer (Fig. 19.5). This is most noticeable at its headwaters which can advance and retreat by the order of 100 metres between a severe drought and wet spring conditions (Fig. 19.6). The headwaters extend further west in winter and spring and recede eastwards during summer as the rate of outflows of groundwater exceeds inflows due to natural gravity drainage or pumping. Changes in flow are less obvious in the lower reaches because the channel is relatively deep and never dries up.

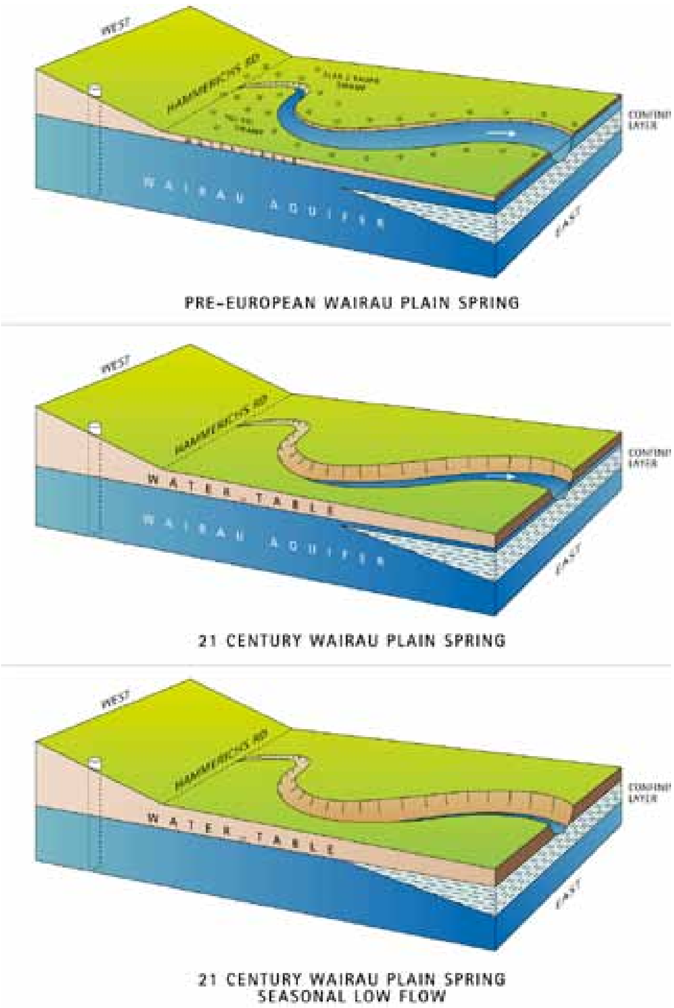

Figure 19.5: Wairau Aquifer and spring interaction

While fish and animals can migrate downstream as spring headwaters recede, extreme droughts such as in the summer of 2000/01 resulted in muddy channels instead of the usual picturesque spring.

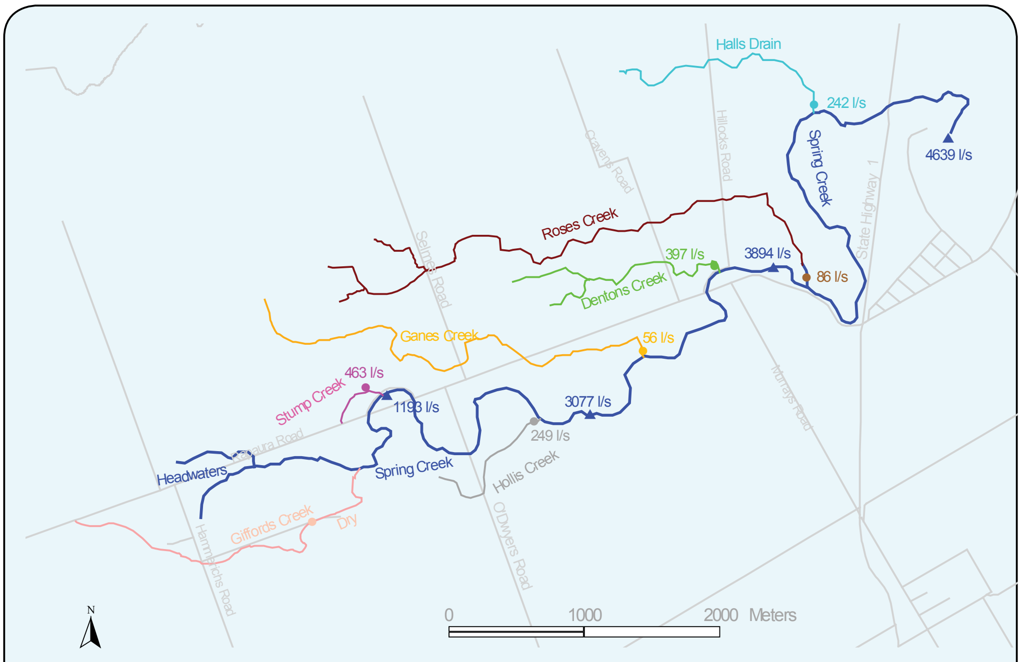

Figure 19.4: Spring Creek channel flows July 1991. The main channel of Spring Creek is in blue and tributaries in other colours. The annotations show the location of the MDC gaugings and measured flows in l/s.

Flow and recharge patterns

Spring Creek is effectively an extension of the Wairau Aquifer which in turn mimics the flow regime of the Wairau River. Fortunately for the inhabitants of the Wairau Plain, the Wairau River flows perennially and maintains stable Spring Creek flows year round.

Figure 19.6: Seasonal variation in the headwaters of Spring Creek. Upper photo taken during 2001 drought. Lower photo taken at typical winter flows.

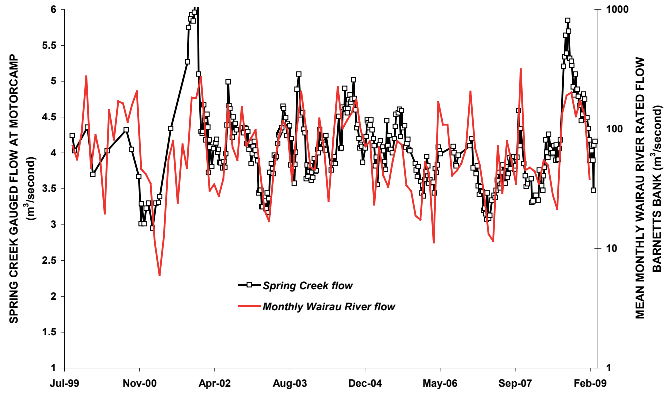

Figure 19.8: Spring Creek gauged flow versus mean monthly Wairau River flow 1999 - 2009

The hydraulic connections between the river, aquifer and spring are evident when the variation in Spring Creek flow at the Motorcamp site is plotted against Wairau Aquifer level at well 3009 in Wratts Road, and mean monthly Wairau River flow (Fig. 19.7 and Fig. 19.8). There is such a close relationship between groundwater elevation and spring flow that the behaviour of either water resource can be predicted from a knowledge of the other. Spring Creek flow at the Motorcamp and mean monthly Wairau River flow at Barnetts Bank are not as closely related as the groundwater levels. This confirms that Spring Creek flow is hydraulically dependant on Wairau Aquifer levels. A better relationship would be shown if a well closer to the Spring Creek flow measurement site was used for groundwater monitoring.

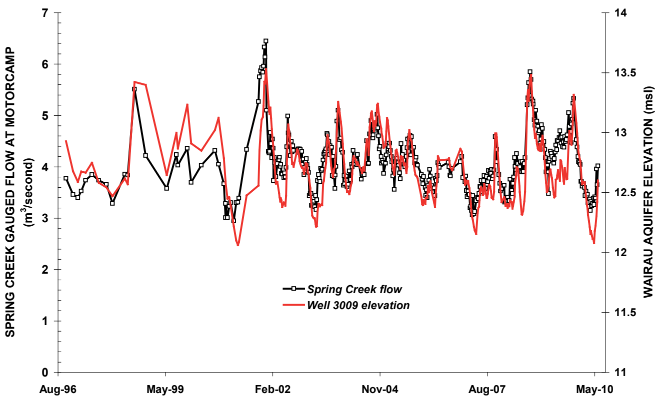

Figure 19.7: Spring Creek gauged flow versus Wairau Aquifer Elevation 1996 - 2010

The relationship between Spring Creek flow and aquifer level is not linear (Fig. 19.9). Spring Creek flow is more sensitive when groundwater levels are above an elevation of 12.5 metres. At this point the expansion of the channel network generates proportionately more flow. For example, an increase in well 3009 level of 0.5 metres produces an increase in channel flow of 1.1 m^3/s when levels are high, compared to 0.75 m^3/s during typical drought conditions.

Another way to look at how Spring Creek responds to external influences is by plotting the seasonal variability in Spring Creek flows (Fig. 19.10). This is called an envelope plot and is based on a water year starting and finishing in July for all the flow observations dating back to 1991. Gauged flow at the Motorcamp site in cubic metres per second is shown on the vertical axis with the red line indicating the level at which significant headwater recession occurs. The shape of the plot shows that large Spring Creek flows presumably caused by local rainfall and Wairau River floods, predominate in spring and to a lesser extent, winter.

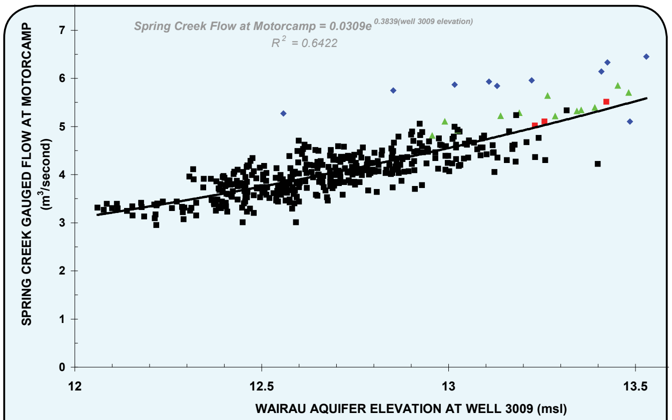

Figure 19.9: Spring Creek flow versus Wairau Aquifer elevation. The coloured marks are high flows caused by rainfall that runs off the land surface surrounding Spring Creek, without increasing aquifer levels

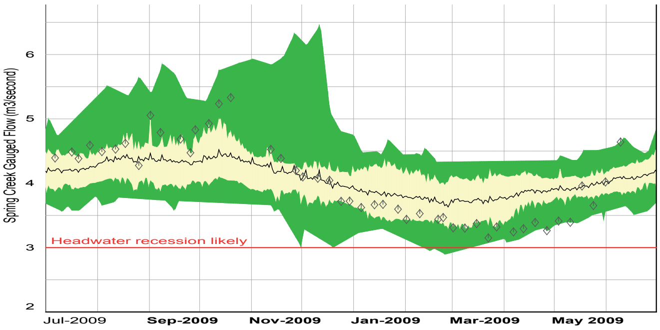

Figure 19.10: Spring Creek flow at motorcamp seasonal variation

The mean flow is marked by the black line with the middle 50 percentile of flows falling within the tan area. The diamonds represents individual gaugings between July 2009 and July 2010 and show that flows oscillated about the mean with a dramatic increase in June 2010 following heavy rain.

Response to rainfall and Wairau River floods

While Spring Creek flow relies primarily on the status of the surrounding Wairau Aquifer, it also responds to floods in the Wairau River and localised rainfall (Fig. 19.11). The runoff generated is potentially significant based on its catchment area of around 1,000 ha. However, separating out rainfall contributions isn't straightforward, as rain events normally coincide with Wairau River floods.

River flood waves travel relatively quickly through the semi-confined or confined portion of the Wairau Aquifer surrounding Spring Creek due to the naturally low storage properties of the gravels. This means the influence of a flood wave can be picked up in wells or freshwater springs several kilometres to the south of the Wairau River channel as it passes by. Conversely, in the unconfined Wairau Aquifer further upstream, any

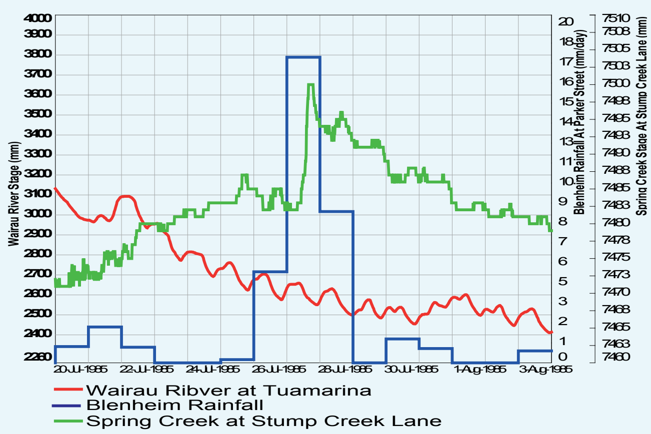

Figure 19.11: Spring Creek response to rainfall. A total of 30 millimetres of rain was recorded at Blenheim while the Wairau River was in recession. The green line shows a rise in Spring Creek stage at Stump Creek Lane of 20 millimetres in response to the rain, which corresponds to an increase in channel flow. Wairau River stage is shown in red. Rainfall at Parker Street in Blenheim is marked in blue and its scale is shown on the middle vertical axis in millimetres per day.

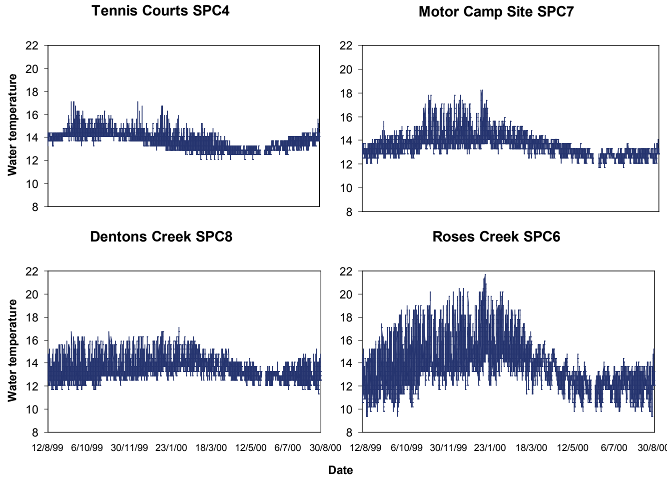

Figure 19.12: Spring Creek water temperature variation (Cawthron - 2000)

changes in Wairau River channel flow are transmitted much more slowly as the pore spaces are much larger and take longer to fill. Generally the influence of fluctuations in Wairau River flow are negligible at distances of greater than about three kilometres from the channel. This is due to the buffering effect of the groundwater stored within the aquifer and is the reason that flood waves are not discernible in Blenheim wells.

Links between the Wairau River, Wairau Aquifer and spring flow are supported by similarities in water chemistry and Oxygen-18 stable isotope results. In the early 1990s Claude Taylor of the DSIR estimated that water derived from infiltration of local rainfall couldn't exceed more than a few percent of total flow through the Wairau Aquifer. By implication, neither could the baseflow of downstream springs like Spring Creek. More recent work by GNS Science (2006) has revised this figure and it is now thought that a higher proportion of Spring Creek flow originates from land surface recharge.

The temperature of groundwater is very constant due to the moderating influence of the large volume of freshwater stored by the Wairau Aquifer. The

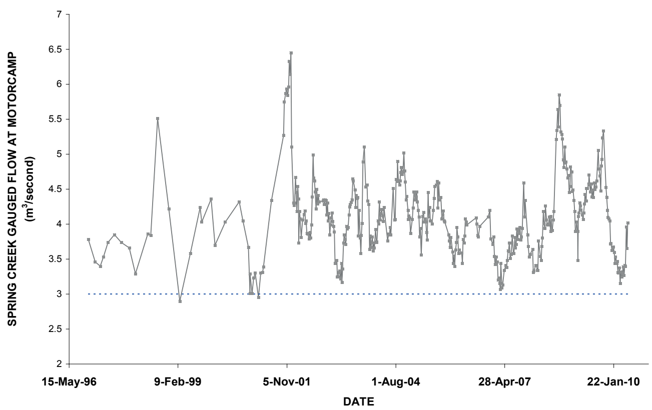

Figure 19.13: Gauged flow record 1996-2010. The dashed horizontal line indicates the flow at the Motorcamp which coincides with significant headwater recession.

Date Range	Median Flow (l/s)	Mean Flow (l/s)	Minimum Flow (l/s)	Maximum Flow (l/s)	Flow Range (l/s)	Standard Deviation (l/s)	Mean Annual Low Flow (l/s)	Coefficient Of Variance
2001 –2010	4030	4070	2898 (Feb. 1999)	6450 (Dec. 2001)	3500	553	3300	0.136

Table 19.1: Spring Creek at motorcamp gauged flow summary

temperature of spring water tends to be similar to that of groundwater which confirm the hydraulic linkage between the groundwater and springs.

A study by the Cawthron Institute in 2000 for the MDC recorded a series of continuous water temperature measurements at four sites. Three of the sites: Tennis Courts, Motor Camp and Dentons Creek are channel reaches which receive major inflows of groundwater recharge. The fourth site, Roses Creek, has a much larger seasonal variation, which is consistent with its longer channel providing more exposure to the sun and greater sensitivity to rainfall. Roses Creek also receives a lower rate of groundwater recharge relative to the other three sites (Fig. 19.12).

Flow regime

The MDC first commenced analysing flow records for Spring Creek in 1996 with the intention of identifying long-term trends in low flows associated with changing patterns in groundwater use. Prior to this only a few isolated gaugings had been made, and only the stage height at Stump Creek had been observed previously (Fig. 19.13).

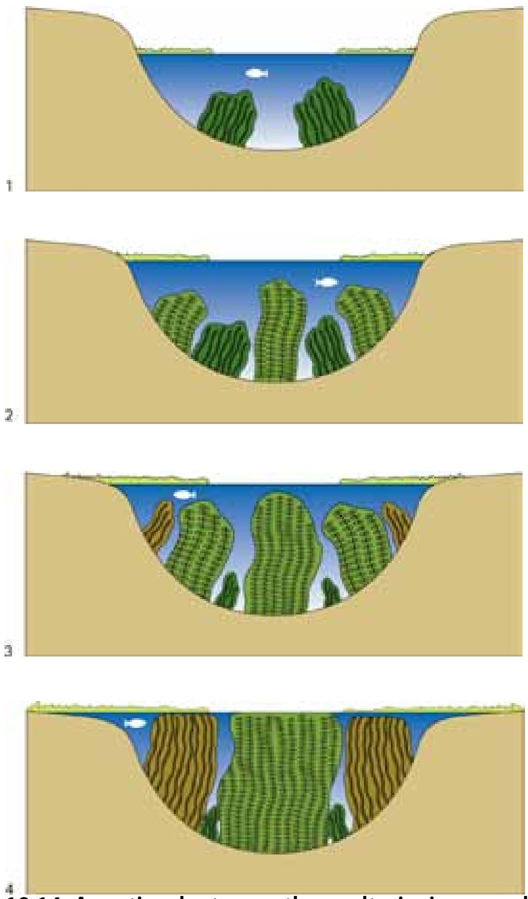

Figure 19.14: Aquatic plant growth results in increased water levels

One of the lowest gauged flows of 2.9 m³/s occurred in February 2001 during the severe summer drought of that season. Later that summer when Spring Creek flow was measured at 3.3 m³/s the Wairau River was only flowing 4 m³/s. In other words, the flow of Spring Creek was equivalent to the flow of the entire Wairau catchment. The highest measured flow of 6.5 m³/s occurred in December 2001 and coincided with the wettest spring Marlborough had experienced in three decades.

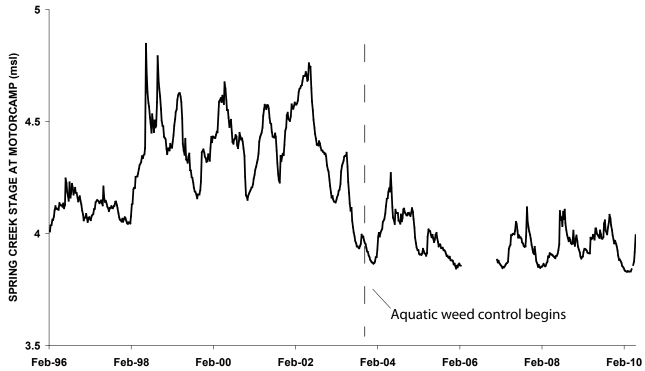

Figure 19.15: Spring Creek stage elevation 1996-2010

The flow characteristics of Spring Creek at the Motor camp site are based on 468 gaugings made by MDC staff (Table 19.1). The median and mean flows both equal 4 m³/s, with a small standard deviation of 0.55 m³/s. The similarity of the mean and median flows demonstrates the stable nature of Spring Creek compared with the Wairau River which has mean flow of 100 m³/s and a median flow of 60 m³/s. The Wairau River is affected by flood flows whereas Spring Creek isn't.

Spring Creek channel flow is remarkably steady over time due to the moderating influence of the associated Wairau Aquifer.

To compare the characteristics of Wairau Plain springs and account for differences between individual systems, we normalise flows using the coefficient of variance, which is the standard deviation divided by the mean flow of a particular spring. Spring Creek has the lowest coefficient of variance for the Wairau Plain springs that are measured weekly.

Influences on Spring Creek flow

A number of factors control the flow of Spring Creek, both natural and man-made. For example, the removal of willow stumps particularly in the lower reaches, can change the hydraulic connection with the Wairau Aquifer and increase channel flow. However the most

Figure 19.16: Spring Creek below floodgates

common influence on flow is caused by aquatic weed growth. Accurately measuring flow in many Wairau Plain waterways can be complicated by weed growth, especially over summer when abundant sunlight causes aquatic plants to bloom. Their extra mass displaces water in the channel, making it appear as if there is a greater depth (Fig. 19.14). For this reason water depth or stage doesn't necessarily correlate accurately with the flow of the spring.

Since approximately 2003 the MDC has actively controlled aquatic plant growth which has resulted in lower channel levels (Fig. 19.15). This is likely to increase the gradient in water level between Spring Creek and the surrounding Wairau Aquifer resulting in higher Spring Creek flows (Fig. 19.16).

Care is needed when applying Spring Creek stage information in isolation. For a brief period in 1985 and during the mid 1990s, the stage height of Spring Creek was measured at Stump Creek Lane. This didn't accurately reflect channel flow, so manual gaugings have been made on a regular basis at the motorcamp site since 1996.

Spring flows are crystal clear because of the high quality groundwater feeding them. Water clarity is amongst the highest in the world and it is important to keep it that way (Fig. 19.17).

References

GNS Science Ltd, 2006. The use of ^{18}O as a groundwater tracer in the Marlborough Region, GNS Science Report 2006/3, M.K. Stewart

GNS Science Ltd, 2008. Age and Source of Wairau Plains Groundwater, Report 2008/18, M.K. Stewart

Taylor, C.B., Brown, L.J., Cunliffe, J.J. and Davidson, P.W. 1992. Environmental tritium and ^{18}O applied in a hydrological study of the Wairau Plain and its contributing mountain catchments, Marlborough, New Zealand, Journal of hydrology, 138, (1992) 269-319

Young, R.G., Strickland, R.R., Harding, J.S., Stark, J.D. and Hayes, J.W. 2000. The Ecology of Spring Creek – Awarua. Prepared for Marlborough District Council and Fish & Game NZ – Nelson-Marlborough Region. Cawthron report No. 611

Figure 19.17: High water clarity of groundwater fed Spring Creek flow at Stump Creek Lane