The Rakaia Selwyn Groundwater Zone – Technical summary of the effects of groundwater abstractions on stream flows and reliability of groundwater

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1. Introduction

1.1 Overview

In July 2006 Environment Canterbury (ECan) began the Restorative Programme for Lowland Streams. The programme aims to increase flows in lowland streams to ensure flows that will meet the requirements of lowland aquatic ecosystems, and improve reliability of supply for water users in the zone. The programme was initiated because instream values are being adversely affected due to lower than normal flows, and the reliability of supply for existing water users has reduced.

Following this, ECan announced its intention to consider reviewing water abstraction consents in the Rakaia-Selwyn groundwater allocation zone (the Rakaia Selwyn zone) in Canterbury. The aim of consent reviews would be to reduce the effects of water abstractions on lowland streams and provide long-term security of supply for existing consent-holders. Groundwater and surface water consents in the Rakaia Selwyn zone will be considered for review to achieve three key outcomes on consents:

1. Place annual limits on the volume of water allocated;
2. Provide for water metering to enable the measurement of actual use of water in the zone; and
3. Restrict groundwater abstractions directly linked to surface waterways during periods of minimum flow.

The fourth aim of the consent review initiative was to provide for varying seasonal limits depending on availability of water in the groundwater system – referred to by ECan as adaptive management or variable annual allocation. However, it has been decided not to consider applying adaptive management conditions to existing consents at this time. It is considered that more time is needed to develop an appropriate method for applying the adaptive management approach to existing consent holders.

1.2 Report Scope

The purpose of this report is to summarise the key information which is relevant to the effects of water abstractions in the Rakaia Selwyn zone. This information includes:

- Technical reports relating to the management of water in Canterbury, and the effects of water abstractions on groundwater and surface waterways.

- Chapter 5 of the proposed Natural Resources Regional Plan (NRRP) and Variation 4 to the PNRRP. This chapter deals with water quantity issues and was notified on July 2004. The variation was publicly notified on 23 June 2007. The plan is not yet operative. However the plan does contain objectives and policies which provide guidance on methods for managing the effects of groundwater abstractions on surface waterways.

- Evidence presented at the resource consent hearing held throughout 2006 to consider multiple consent applications to take and use groundwater in the Rakaia-Selwyn Groundwater Allocation Zone.

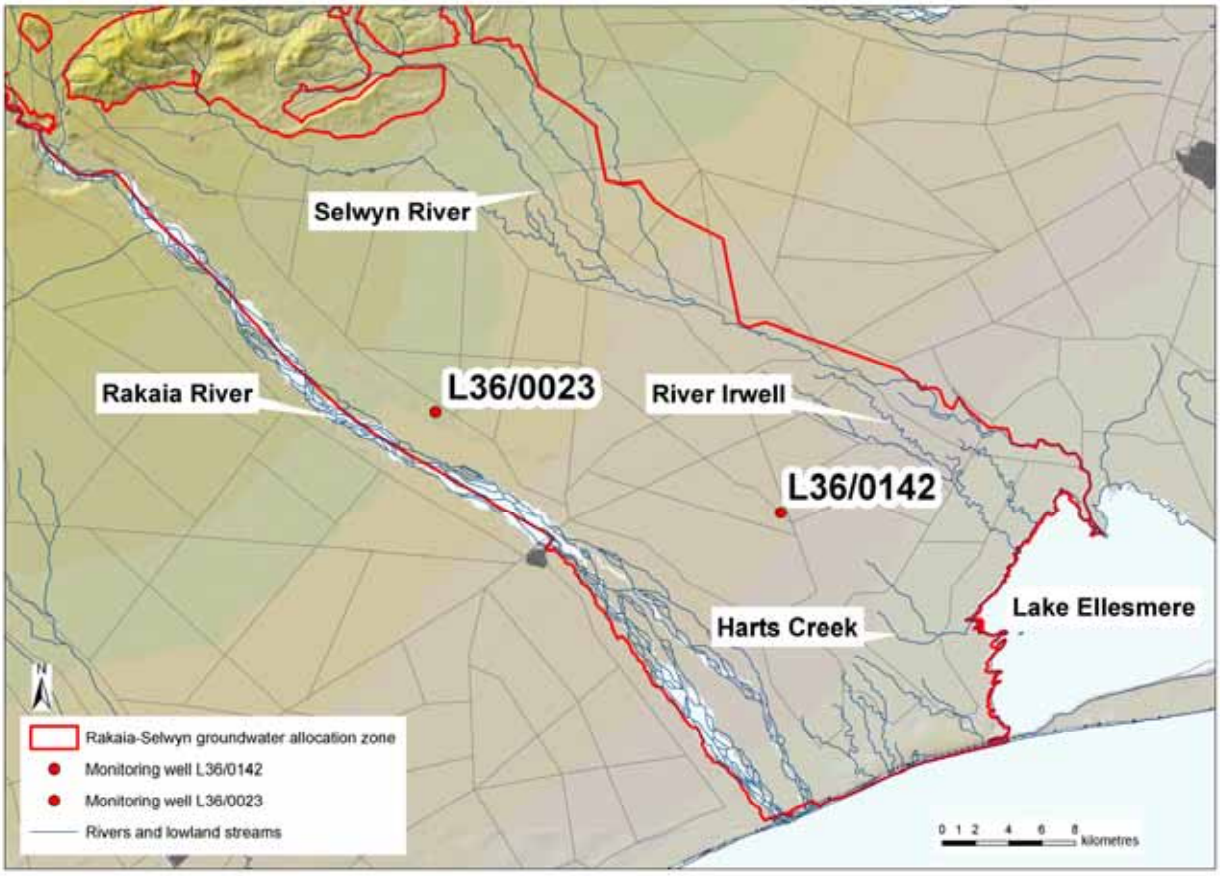

Figure 1.1: Map showing location of Rakaia-Selwyn groundwater allocation zone, waterways and monitoring wells named in text.

2. The Rakaia Selwyn Groundwater Zone

2.1 Introduction

The Rakaia-Selwyn Groundwater Allocation Zone was identified by ECan in 2004 (Environment Canterbury, 2004a). The location of the Rakaia-Selwyn Groundwater Allocation Zone is shown in Fig. 1.1. The zone covers an area of 128,452 hectares and forms the larger part of the Central Plains area between the Waimakariri and Rakaia rivers.

Chapter 5 of the proposed NRRP and the proposed Variation 4 sets out a groundwater allocation regime and allocation limits for each groundwater zone in Canterbury. A zone is considered to be over-allocated where ECan's assessment shows that the total amount of groundwater currently allocated exceeds the allocation limit. Up-to-date information about the effective allocation (as defined in the proposed NRRP) for all groundwater zones is available from ECan's website (www.ecan.govt.nz). As of 22 June 2007, the effective allocation for the Rakaia Selwyn Zone is 223.90 million m^3/year, which is 104.1% of the proposed allocation limit. Therefore the Rakaia Selwyn Zone is considered to be more than fully allocated, and categorised as a red zone.

2.2 Water resources issues in the Rakaia Selwyn Zone

In the Rakaia-Selwyn zone, surface water and groundwater are highly connected. Changes in groundwater level induce changes in the flow of spring-fed streams. Streams in the upper part of the

catchment lose water to the ground; in the bottom part of the catchment, groundwater discharges to surface.

There are data that show groundwater levels and stream flows are reducing in the Rakaia-Selwyn Groundwater Allocation Zone (Figure 2.1).

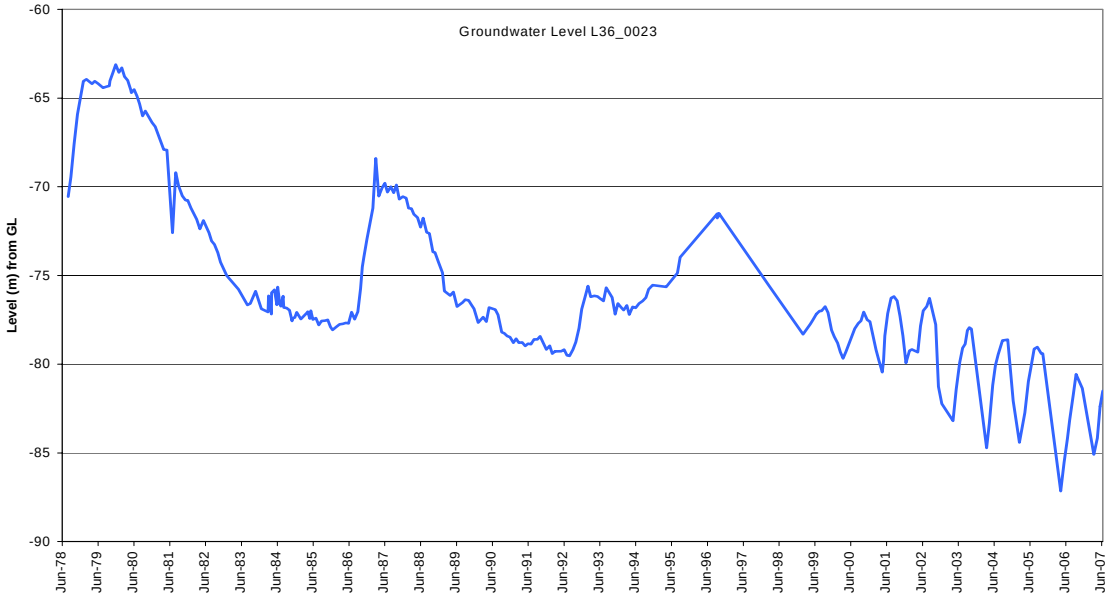

Figure 2.1: Plot of groundwater levels as monitored in bore L36/0023 (108.8 m deep) at Te Pirita

In the inland and mid-plains areas of the zone, groundwater levels have shown an inter-seasonal declining trend, particularly from 2002-2006, with current groundwater levels at similar or lower than levels during a dry period in the 1970's (Williams and Aitchison-Earl, 2006). Monitoring records show that the seasonal range in groundwater levels within individual wells is greater than at any time in the monitoring record. Some measurements suggest that drawdown can begin at the start of an irrigation season before full recovery from the previous season has been completed. Two examples are shown in figures 2.1 and 2.2.

Note that Figure 2.2 includes the 55 years of monitoring. With the exception of those flowing from within the Little Rakaia Zone south of Southbridge, the majority of flows in streams within the Rakaia-Selwyn Groundwater Allocation Zone are reducing (Horrell, 2006). The average number of openings per year of Lake Ellesmere/Te Waihora is also decreasing from 3.6 to 2.6 openings per year, causing the residence time of water in the lake to increase (Horrell 2006).

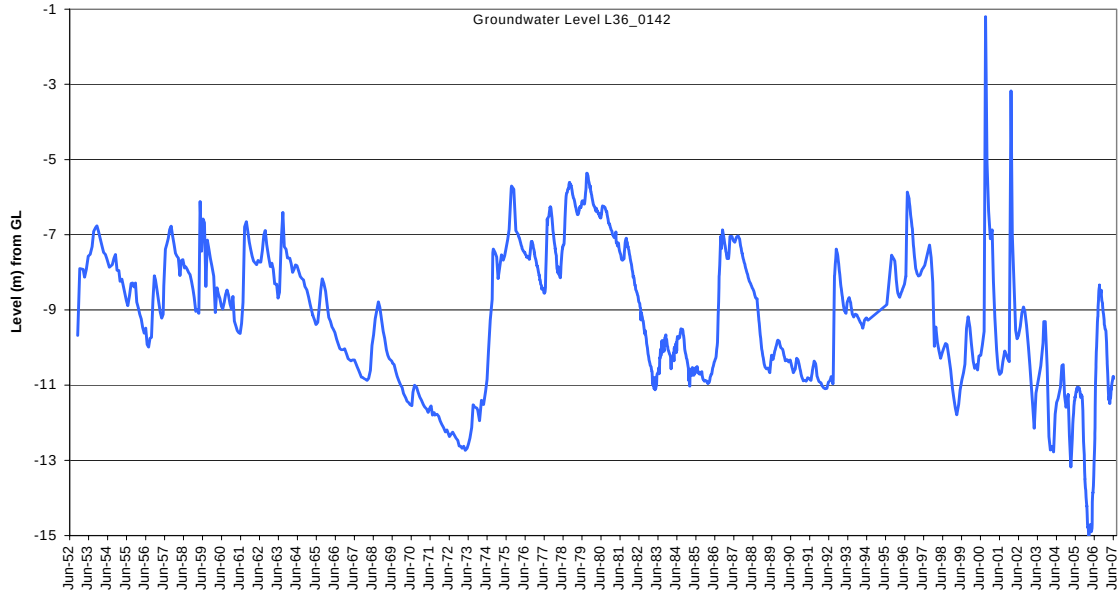

Figure 2.2: Plot of groundwater levels as monitored in bore L36/0142 (16.3 m deep) at Irwell-Rakaia Road

2.3 Effects of lowered groundwater levels and stream flows

2.3.1 Effects on water users

Reduced groundwater levels impact on groundwater users, and can cause supplies to dry up, or become less reliable. Anecdotal evidence from newspaper reports and complaints to Environment Canterbury indicates that groundwater users are being affected through wells going dry, or having a reduced yield. Similarly, reduced flows in streams may impact on both groundwater and surface water users who are subject to consent conditions requiring them to cease taking water when minimum flows are reached. There is some evidence that the reliability of supply to these consent holders is decreasing, as the length of time that streams are on restrictions or without flow has increased. Horrell (2006) presents data indicating that the Irwell was on restriction for 60 days in 1973/4, and the frequency of restrictions has increased to a mean value of 150 days per year in the last five years.

2.3.2 Effects on water quality and aquatic ecology

The surface waterways within the Rakaia-Selwyn Groundwater Allocation Zone have a range of values from limited value to very high cultural and ecological value (Hayward, 2006). The lowland streams feed into Lake Ellesmere/Te Waihora, which is recognised as one of New Zealand's most important wetland systems, and has very high cultural, ecological and commercial values. The streams and drains in the zone contribute about half to three-quarters of the water inputs to the lake, and reductions in inflows of freshwater may have significant impacts on lake ecosystem functioning (Hayward, 2006).

The water quality in the lowland streams in the Rakaia-Selwyn Groundwater Allocation Zone is typical of lowland streams in Canterbury, with the exception of the Irwell River (Hayward, 2006). Available data for the Irwell River shows that there has been a serious deterioration in the water quality and habitat value in the Irwell River as a result of low flows and dry periods (Hayward, 2006). The Irwell River is considered to be an indicator of the type of effects associated with severe flow reduction. For other waterways in the zone, such as the Selwyn River/Waikirikiri, Harts Creek and Birdlings Brook, moderate to high ecological

and fishery values have been maintained, but are in serious threat of decline as a result of diminishing flows (Hayward, 2006).

While land use activities and stream maintenance works will also impact on stream health, there is evidence that declining base flows also contribute to the poor stream health (Hayward, 2006). Further loss of base flow in the lowland streams is likely to result in further and more permanent deterioration in stream health, which, combined with a loss of suitable physical habitat, is likely to result in the decline and possible permanent loss of sensitive invertebrate and fish species (Hayward, 2006). As winter baseflows decline over time, spawning gravels become unsuitably shallow for spawning trout. There is evidence that trout spawning reaches in the headwaters of the tributaries have lower baseflows than in the past, and lower numbers of spawning trout (Taylor, 2006). It is likely that in waterways throughout the Rakaia-Selwyn Groundwater Zone, lower baseflows, combined with poor riparian management, has adversely affected trout spawning reaches (Taylor, 2006).

2.4 Causes of lowered groundwater levels and stream flows

2.4.1 Climatic factors

Climatic variation will contribute to reduced rainfall recharge to groundwater, and hence reduced flows in streams. However, work done to date indicates strongly that the observed declines in groundwater levels and stream flows is not solely caused by changes in rainfall recharge (Williams, 2006). Data from the National Institute of Water and Atmospheric Science (Figure 2.3) demonstrates a slight decrease in monthly mean rainfall over the past 35 years.

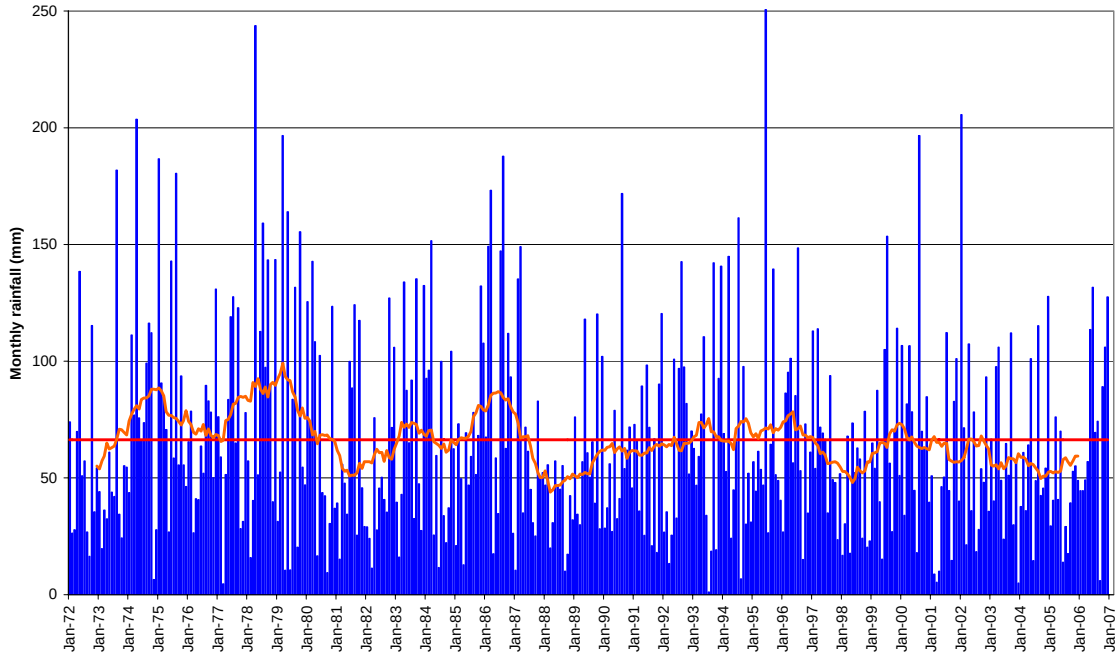

Figure 2.3: Plot of calculated monthly rainfall within the Rakaia-Selwyn groundwater allocation zone from data provided by NIWA. Red line represents monthly mean rainfall, orange line represents trend of 24-monthly mean.

2.4.2 Water Abstractions

Estimated volumes of groundwater allocation to resource consents have increased five-fold, from 42 million cubic metres to 228 million cubic metres since 1990, with the most rapid increases occurring after 2000 (Scott, 2006). Groundwater abstraction has increased to the extent where it is now a major part of the water budget for the Rakaia-Selwyn zone with the allocated amount of groundwater of 223.9 million

cubic metres per year being a significant proportion of the estimated mean annual land surface recharge of 381.2 million cubic metres per year (Scott, 2006). Therefore groundwater abstractions are likely to be having a significant impact on groundwater levels in the zone (Williams, 2006).

Abstractions of surface water from lowland streams will have a direct effect on flows in the streams. Groundwater abstractions affect surface waterways through the following processes:

1. The direct effect of individual wells in the vicinity of flowing streams and springs (predominantly within 2 km, but dependent on the abstraction rate) over an irrigation season;
2. The effects of all groundwater abstractions that result in cumulative changes of stream and spring flows over an irrigation season;
3. Inter-seasonal, cumulative changes causing regional scale lowering of groundwater levels, and consequently, reducing flows into surface water ways.

Of these, the localised direct effects on streams can be managed by minimum flow conditions on consents for surface water abstractions and abstractions of hydraulically connected groundwater.

ECan carried out a preliminary desktop assessment to estimate the stream depletion effects of groundwater abstractions on lowland streams in the Rakaia-Selwyn Groundwater Allocation Zone (Environment Canterbury, 2006). The assessments were carried out in accordance with the guidelines in Chapter 5 of the proposed NRRP. The desktop assessment identified 130 consented abstractions which are likely to be hydraulically connected to streams and having a stream depletion effect. The total estimated stream depletion rate is 3073 L/s, of which 2610 L/s is assessed as having a low, moderate or high degree of hydraulic connection with surface waterways in accordance with Policy WQN8 of the PNRRP. The remainder of the effect would not be managed through minimum flow conditions under Policy WQN8 of the proposed NRRP. This suggests that impacts on flows in lowland streams can be reduced by the review of any consents abstracting hydraulically connected groundwater which are not currently subject to minimum flow conditions.

In addition to the direct impacts of hydraulically connected wells, there is evidence indicating that the reduced flows in lowland streams could in part be due to the cumulative effect of groundwater abstractions in the zone (Horrell, 2006). This is based on ECan records which show that for most streams, the number of surface water takes and shallow groundwater takes have not increased since 1990, whereas the number of deeper groundwater takes has increased. Streams showing declining flows have not exclusively experienced increases in direct surface abstraction or shallow groundwater abstraction.

A recent investigation into trends in the lower Selwyn River flows also suggests that water abstractions throughout the zone are contributing to reduced stream flows (McKerchar and Schmidt, 2007). In this study, Selwyn River flows monitored upstream at Whitecliffs from 1964 and downstream at Coes Ford since 1984 were compared to recharge and soil moisture deficit data. A multiple linear regression equation was developed to predict seasonal low flows at Coes Ford. A comparison of the predicted trend with observed values showed that the predictions provided were very good estimates of 90-day low flow events at Coes Ford. The trend implies that the low flows at Coes Ford have decreased at a rate of about 32 L/s per year over the 22 year period, after the effect of recent low-rainfall years is accounted for. The trend term in the equation is consistent with increased abstractions from Central Plains groundwater over the period of the recording. While it is concluded that the increase in irrigation abstractions is one reason for the decrease in flows, the impact is difficult to quantify without measurement of irrigation abstractions and data on irrigated area and irrigation use.

2.5 Proposed management of water allocation in the Rakaia Selwyn Zone

There is a range of management options to restore flows in waterways as part of the Lowland Streams Programme. Many are non-regulatory, and fall outside the consent review process. Of the regulatory methods, the four key outcomes that could be achieved through the consent review process are; setting

limits on the amount of water abstracted annually, measurement of water use, minimum flow conditions, and adaptive management of water abstracted each season. As discussed earlier, ECan is not seeking to apply adaptive management conditions to existing consents at this time, as further work and consultation with consent holders needs to occur prior to a suitable adaptive management regime being devised. The other three outcomes being sought are outlined below.

2.5.1 Management of water abstracted seasonally.

The annual allocation limit is a coarse mechanism to limit abstractions to a volume able to be recharged and still allow an acceptable natural discharge from the groundwater system to be maintained. A varying seasonal limit (or adaptive management) is required to maintain the natural discharge of the system, or maintain groundwater levels, taking into account the recharge history and current resource state.

Schedule WQN9 and Policy WQN17 of the PNRRP will be used for guidance in determining reasonable and efficient use of water. Schedule WQN9 (Variation 2) of the PNRRP describes the methodology for determining seasonal irrigation demand (Environment Canterbury, 2005). Under the Schedule, seasonal irrigation demand is determined using land use, soil types, and effective irrigation season rainfall. The methodology uses values from Table WQN24 and Figure WQN12. Table WQN24 provides the total seasonal demand for different land uses and soil types. Figure WQN12 provides a map of effective irrigation season rainfall for northern and central Canterbury.

2.5.2 Measurement of water abstractions.

It is essential that water abstractions are accurately measured to allow for effective management of a water resource. Without accurate measurement of the volume of groundwater actually used, a comprehensive assessment of the state of the resource and the mechanisms by which the components of the resource respond to stress is uncertain. Therefore the requirement for flow meters and data loggers to measure and record water use will assist ECan in making decisions on water allocation, and effectively manage the resource.

2.5.3 Minimum flow conditions

The setting of minimum flow conditions on consents allows the direct impact of water abstractions on stream flows to be managed, as required under Policy WQN3 of the PNRRP. As discussed in section 2.4.2 of this report, a desktop study by ECan suggested that there could be approximately 130 consented groundwater abstractions having a direct impact on stream flows in the Rakaia Selwyn Zone. These consents will be considered further for review to determine if low flow conditions should be applied to these consents. The method set out in Policy WQN8 of the PNRRP will be the main method used to determine if low flow conditions are necessary, and in accordance with the policy, low flow conditions should be applied to any water takes considered to have:

- A high degree of hydraulic connection to a surface waterway (calculated for a seven day pumping period); or
- A moderate degree of hydraulic connection (calculated over a 150 day pumping period) and an estimated stream depletion effect exceeding 5 L/s.

For the preliminary assessment to determine which consents should be reviewed, the Jenkins (1977) method has been commonly used to assess potential stream depletion effects. It is acknowledged that other methods, such as the Hunt (1999), and Hunt (2003) method, may be more appropriate if sufficient data describing aquifer hydraulics and stream-bed clogging are available.

All surface water consents in the Rakaia Selwyn Zone will also be considered for review if they do not already include a low flow condition.

3. Summary of Proposed Review Outcomes

The potential review outcomes and the issues that they are related to are outlined below, with references to the key reports. These issues all relate to the key effects of concern - the impact on lowland stream ecology due to reduced stream flows, and the issue of reliability of supply for groundwater users.

Proposed review outcome	Issues	Key references
Annual allocation limits.	▪ Reasonable and efficient use of water. ▪ Cumulative effects on groundwater levels and consequently lowland stream flows. ▪ Reliability of supply for groundwater users.	▪ PNRRP – Chapter 5. ▪ Evidence from Rakaia Selwyn groundwater zone consent hearings. ▪ ECan report U04/02 on groundwater allocation limits.
Water metering to measure actual use.	▪ Lack of certainty about actual amount of water abstracted in the Rakaia Selwyn groundwater allocation zone, makes it difficult to determine the impact of abstractions on stream flows. ▪ Will enable compliance with consent allocation limits to be monitored, which will help manage reliability of supply issues, and impacts on stream flows.	▪ McKercher, A., and Schmidt, J (2007). ▪ PNRRP – Chapter 5. ▪ ECan report U04/02 on groundwater allocation limits.
Low flow restrictions on all surface water takes, and groundwater takes with high, medium or low connection (as per NRRP).	▪ Direct effects of abstractions on lowland stream flows.	▪ ECan report U06/03 on stream depletion effects within the Rakaia Selwyn Zone. ▪ Evidence from Rakaia Selwyn groundwater zone consent hearings. ▪ PNRRP – Chapter 5.

Howard Williams.
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