Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Memo

Date	02/05/18 – Version 4
To	Waimakariri Water Zone Committee
cc	-
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Environmental flow regime options for the Waimakariri River Northern Tributaries

1 Summary

This memorandum summarises the current status of environmental flow regime (allocation, minimum flow, partial restrictions) in the northern tributaries of the Waimakariri River, describes current issues and presents an analysis of future environmental flow regime options and their ability to address Zone Implementation Programme (ZIP) and NPS for Freshwater Management objectives. There are eleven surface water allocation zones (SWAZ) defined within the Waimakariri River Regional Plan (WRRP) (Table 1). These do not cover the entire Waimkakariri River northern tributaries area and as such a number of SWAZ which do not appear in the WRRP are also used by Environment Canterbury in the management of water (Table 2).

Table 1 – WRRP SWAZ

Cam River catchment			
Cam River/Ruataniwha SWAZ	Northbrook SWAZ	Middlebrook SWAZ	Southbrook SWAZ
Cust River catchment			
Cust River SWAZ	Cust Main Drain SWAZ	No.7 Drain SWAZ	
Ohoka Stream catchment			
Ohoka Stream SWAZ			
Kaiapoi River catchment			
Kaiapoi River / Silverstream SWAZ			
Courtenay Stream catchment			
Courtenay Stream SWAZ	Greigs Drain SWAZ		

Table 2 – Non-WRRP SWAZ

Eyre River SWAZ
View Hill Creek SWAZ
Eyre River Water Race SWAZ
Waimakariri River (below woodstock) SWAZ
Waimakariri Water Race SWAZ
Bennetts Creek SWAZ
Macintosh Drain SWAZ
Saltwater Creek SWAZ

A number of issues have been identified which are common across the Waimakariri River northern tributaries area:

- SWAZ boundaries do not follow catchment boundaries in some locations
- Parts of the area are not covered by WRRP SWAZ which results in them not having an allocation, creating ambiguity for potential water users.
- The method used to assess stream depletion potential for groundwater takes is inconstant with methodology laid out in the WRRP
- Unlimited 'B' block allocations are available for all rivers. Unlimited blocks are a poor management approach and 'B' blocks are generally unsuitable for spring-fed streams

In addition, a number of SWAZ specific issues have also been identified:

- Surface water in the some SWAZ is over-allocated
- Allocation limits are generally higher than typical ecological metrics suggest would be appropriate
- Minimum flows are generally lower than typical ecological metrics suggest would be appropriate
- Minimum flows are sometimes lower than the cultural aspirations for the catchments
- Some rivers may experience a decline in the available water due to increased use of groundwater and/or climatic trends
- Ecological and cultural values are compromised in each SWAZ
- Where multiple SWAZ exist in a catchment the allocations and minimum flows are not aligned, resulting in poor outcomes for the wider catchment.

To keep the number of scenarios considered to a reasonable level each of the area-wide issues have been assessed, and then used as a basis upon which to assess the SWAZ-specific issues. This is important, because if any of the area-wide recommendations are not pursued by the Zone Committee then the impact of this will need to be reconsidered at the SWAZ level.

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The outcome of this work is a list of environmental flow management options which can be pursued by the Zone Committee, and ultimately the community, to identify a recommended management regime. Broadly, these options include:

- Changing the method for assessing stream depletion rates
- Amending SWAZ boundaries as required
- Removing B blocks from spring-fed rivers
- Providing area-wide coverage of SWAZ
- Increasing minimum flows to offer greater protection of ecological and cultural values; *or*
- Maintaining current minimum flow levels to ensure values do not get worse
- Decrease allocation limits to offer greater protection of ecological and cultural values;*or*
- Maintain current allocation limits to ensure current values do not get worse
- Focus on resolving the over-allocation in a number of catchments
- Creating equality within catchments for allocation and minimum flow
- Implement other mitigations which, along with options above can produce an overall net benefit to catchment values.

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2 Introduction

This memorandum presents the rationale behind options for environmental flow and allocation regimes in the Waimakariri River northern tributaries area. Management is current achieved through limits set across nineteen surface water allocation zones (SWAZ). Eleven SWAZ are defined in the WRRP (Table 1), the remaining eight have been defined for the purpose of managing abstractions in areas not covered by the WRRP SWAZ (Table 2).

In this memorandum we summarises the potential changes to the WRRP designated SWAZ and identify how certainty can be created for the non-WRRP SWAZ.

Typically, rivers in this area are spring-fed streams, rising on the lower plains and flowing into the Waimakariri River before it reaches the coast. They have higher base-flows relative to hill-fed streams that typically drop steadily over the summer months in response to the seasonal reduction in groundwater levels. Flow in the spring-fed streams located closer to the Waimakariri River show a strong link to flows in the Waimakariri River; the strength of this link diminishes as distance increases from the river.

A small number of atypical streams are also present; these being the Cust and Eyre Rivers. Cust River is a hill fed, gravel-bed river which rises on foothills to the east of Mt Oxford. Eyre River rises on the higher slopes of Mt Oxford itself. Low flows dominate these rivers, particularly during summer when they often have reaches which are dry. Low flows are interspersed with larger fresh and flood flows which modify the channels, move gravel and remove macrophytes and algal growth. In their lower reaches the receive spring-flow and show characteristics similar to spring-fed streams.

Given the very different character of the spring-fed and hill-fed rivers, the issues which they face and the management options which can be adopted, are quite different.

To assess the rivers, their current management and future options we have undertaken the following work:

1. Current resource and trends in that resource (*Land and water solutions programme current state hydrology report - Draft*)
2. Current consent water and how that water is used (*Land and water solutions programme current state hydrology report - Draft*)
3. Current issues / values (COMAR, Evaluation of environmental flow regime options for the Waimakariri Northern Tributaries, Groundwater allocation modelling results for northern Waimakariri tributaries catchment)
4. Options available to contribute towards outcomes (*this memo*randum)

3 Purpose

The framework for the development of management options for all watercourses across the country is the NPS for Freshwater Management (NPSFM-14). This document requires that all councils meet five objectives:

Objective B1 To safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the taking, using, damming, or diverting of fresh water.

Objective B2 To avoid any further over-allocation of fresh water and phase out existing over-allocation.

Objective B3 To improve and maximise the efficient allocation and efficient use of water.

Objective B4 To protect significant values of wetlands and of outstanding freshwater bodies.

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Objective B5 To enable communities to provide for their economic well-being, including productive economic opportunities, in sustainably managing fresh water quantity, within limits.

This memorandum summarises the current status of allocation and environmental flows in the Waimakariri Northern Tributaries area, describes the issues and presents the analysis of options and their abiliy to address the five objectives. This information will support the Zone Committee to begin the decision making process for this area.

The options for revised allocations and environmental flows result in various environmental, cultural and economic outcomes. The balance between which varies from option to option.

Maps for each catchment (SWAZ) are provided in Appendix A.

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4 Current state of surface water

The current status of water management in the catchment is described below and is broken down into the three main elements of the management regime (allocation, minimum flow & partial restrictions). The regimes are also presented graphically in Appendix B.

4.1 Allocation

'A' block surface water allocation in a number of catchments is over-allocated (Table 3). 'B' block allocations are generally unused, with the exception of three consents spread across the area; only one of these consents falls within a WRRP SWAZ.

Most consents are for irrigation and stockwater with a small amount for municipal water supply and industrial use.

The over-allocation is a key issue which must be dealt with and this impacts on the options for these streams, as discussed in this document. SWAZ marked with a (*) are non-WRRP SWAZ.

The stream depletion component of the allocation is estimated using the 30-day assessment defined within the WRRP.

Table 3 – Current allocation summary

SWAZ	A permits			B permits		
	Allocation Limit (L/s)	Allocated water (L/s)	Allocated water (%)	Allocation Limit (L/s)	Allocated water (L/s)	Allocated water (%)
Cam River	700	277	40 %	Unlimited	-	-
Northbrook	200	193	97 %	Unlimited	-	-
Middlebrook	30	29	97 %	Unlimited	-	-
Southbrook	100	49	49 %	Unlimited	-	-
Cust River	290	400	138 %	Unlimited	100	n/a
Cust Main Drain	690	822	119 %	Unlimited	-	-
No. 7 Drain	130	85	65 %	Unlimited	-	-
Ohoka Stream	500	484	97 %	Unlimited	-	-
Kaiapoi River	1000	534	53 %	Unlimited	-	-
Courtenay Stream	140	157	112 %	Unlimited	-	-
Greigs Drain	70	32	46 %	Unlimited	-	-
Eyre River*	No limit set	543	n/a	No limit set	-	-
Coopers Creek*	No limit set	60	n/a	No limit set	-	-
Washpen Creek*	No limit set	-	n/a	No limit set	6.5	n/a
View Hill Creek*	No limit set	-	-	No limit set	100	n/a
Burgess Creek*	No limit set	154	n/a	No limit set	-	-
Old Bed Eyre River*	No limit set	258	n/a	No limit set	-	-
Waimakariri Water Race*	No limit set	76	n/a	No limit set	-	-
Bennetts Creek*	No limit set	27	n/a	No limit set	-	-
Total	**3850**	**4180**	-	**Unlimited**	**206.5**	**-**

4.2 Minimum flows

Minimum flows have been set in the WWRP (Table 4). For each SWAZ this is the river flow rate below which all takes must cease.

Consents in this area underwent a consent review. The majority of consents therefore comply with the rules in the WRRP; this is not the case in other areas. The high rate of compliance with WRRP rules mean that the WRRP minimum flows (Table 4) are effectively fully implemented and these can be considered the baseline from which to assess options for future management.

Table 4 – Current minimum flows

<table>
<tr><th rowspan="2">SWAZ</th><th colspan="2">Minimum flow (L/s)</th></tr>
<tr><th>A permits</th><th>B permits</th></tr>
<tr><td>Cam River</td><td>1,000</td><td>1,700</td></tr>
<tr><td>Northbrook</td><td>530</td><td>730</td></tr>
<tr><td>Middlebrook</td><td>60</td><td>90</td></tr>
<tr><td>Southbrook</td><td>140</td><td>240</td></tr>
<tr><td>Cust River</td><td>20</td><td>310</td></tr>
<tr><td>Cust Main Drain</td><td>230</td><td>920</td></tr>
<tr><td>No. 7 Drain</td><td>60</td><td>190</td></tr>
<tr><td>Ohoka Stream</td><td>300</td><td>800</td></tr>
<tr><td>Kaiapoi River</td><td>600</td><td>1,600</td></tr>
<tr><td>Courtenay Stream</td><td>260</td><td>400</td></tr>
<tr><td>Greigs Drain</td><td>150</td><td>220</td></tr>
<tr><td>Eyre River*</td><td colspan="2" rowspan="8">1. No minimum flow set in WRRP for these SWAZ.
2. Where an active consent exists minimum flows may be included in the consent.
3. Where no active consent exists there is no guidance in the WRRP as to the appropriate minimum flow</td></tr>
<tr><td>Coopers Creek*</td></tr>
<tr><td>Washpen Creek*</td></tr>
<tr><td>View Hill Creek*</td></tr>
<tr><td>Burgess Creek*</td></tr>
<tr><td>Old Bed Eyre River*</td></tr>
<tr><td>Waimakariri Water Race*</td></tr>
<tr><td>Bennetts Creek*</td></tr>
</table>

4.3 Partial restrictions

Partial restrictions apply above the minimum flow and begin to reduce takes once a trigger flow has been reached in the river. The trigger flow is the sum of the minimum flow and allocated water up to the allocation limit. The WRRP (*Rule 5.1 (d) (2)*) requires pro-rata partial restrictions to be applied to all consented takes. Because of the consent review process the majority of consents include the partial restriction clause. Given that both the WRRP and WRRP require partial restrictions it can be expected that the pending sub-regional planning process will preserve these restrictions. We have not assessed the effects of an amended partial restriction regime.

4.4 Water use

Current water use was assessed for the water year 2014-15. The data for water used is taken from water meter returns. Where returns were not available water use was estimated using data from similar takes and rainfall/evaporation data.

The 2014-15 year was exceptionally dry and therefore represents a year of high water use. Water use was assessed on a percentage of available water basis. This looks at the restrictions in the peak water use month (January) and estimates the available water based on consent restrictions. The available water is then compared to the water used in that month. This analysis could not be undertaken for all SWAZ.

Table 5 – Peak month water use as % of restricted volume

Cam River	100%
Northbrook	100%
Middlebrook	Not available
Southbrook	100%
Cust River	100 %
Cust Main Drain	79 %
No. 7 Drain	Not available
Ohoka Stream	57 %
Kaiapoi River	70 %
Courtenay Stream	Not available
Greigs Drain	Not available
Eyre River*	Not available
Coopers Creek*	Not available
Washpen Creek*	Not available
View Hill Creek*	Not available
Burgess Creek*	Not available
Old Bed Eyre River*	Not available
Waimakariri Water Race*	Not available
Bennetts Creek*	Not available

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5 Area-wide scenarios

There are a number of issues which apply across the whole northern Waimakariri River tributaries area. These are presented below, and form the basis of the SWAZ specific analysis presented in Sections 6 and 7.

5.1 SWAZ boundary changes and infilling

SWAZ boundaries should generally follow surface catchment boundaries and delineate surface water resources into discrete units. The current boundaries were reviewed and changes were identified to align the boundaries as above. The boundary changes identified result in changes to the allocation totals for SWAZ as some consents are allocated into different SWAZ (Table 6). Revised SWAZ boundaries are provided in Appendix 1.

In addition to amending boundaries we have also defined SWAZ to provide full coverage of the area. The environmental flow regime for these SWAZ are described in Section 7.

Table 6 – SWAZ boundary assessment

Existing SWAZ name	Revised SWAZ name	Current SWAZ boundaries (L/s)		Revised SWAZ boundaries (L/s)		Diff (L/s)
		SW 'A' (L/s)	SW 'B' (L/s)	SW 'A' (L/s)	SW 'B' (L/s)	SW TOTAL (L/s)
Cam River	Cam River	169	-	83	-	**-86**
North Brook	North Brook	94	-	139	-	**45**
Middle Brook	Middle Brook	29	-	29	-	**0**
South Brook	South Brook	-	-	60	-	**60**
Cust River / Bennetts Creek	Cust River	265	100	265	100	**0**
Cust Main Drain	Cust Main Drain	544	-	544	-	**0**
No. 7 Drain	No. 7 Drain	55	-	36	-	**-19**
Ohoka Stream	Ohoka Stream	20	-	20	-	**0**
Kaiapoi River	Silverstream	92	-	92	-	**0**
Courtenay Stream	Courtenay Stream	37	-	23	-	**-14**
Greigs Drain	Greigs Drain	32	-	46	-	**14**
Burgess Creek	Upper Ohoka Stream	-	-	-	-	**-**
Old Bed Eyre River / Waimakariri Water Race / View Hill Creek	Eyre River		*100*	-	100	**0**
Coopers Creek / Washpen Creek	Upper Eyre River	*60*	*7*	67	-	**0**
Macintosh Drain / Kairaki Creek	Coastal Streams	-	-	-	-	**-**
-	Total	**1604**		**1604**		**0**

5.2 Stream depletion methodology

We undertook an assessment of the effects of changing from the WRRP methodology for quantifying stream depletion to the WRRP methodology. For both methods we undertook a Theis-based assessment of stream depletion rate (Table 6). It should be noted that this affects only the stream depletion component of the allocation. It does not affect the direct surface water component of allocation.

Table 6 - Stream depletion methodology assessment

	SD30 (L/s)	SD150 (L/s)	Diff (L/s)
Cam River	108	72	**37**
North Brook	99	130	**-31**
Middle Brook	-	-	**0**
South Brook	49	21	**28**
Cust River	135	162	**31**
Cust Main Drain	278	332	**-54**
No. 7 Drain	29	33	**-3**
Ohoka Stream	464	438	**27**
Silverstream/ Kaiapoi River	449	357	**92**
Courtenay Stream	120	111	**10**
Greigs Drain	-	-	**0**
Upper Ohoka Stream	123	120	**2**
Eyre River	877	1037	**-160**
Upper Eyre River	-	-	**0**
Coastal Streams	32	31	**1**
Total	**2822**	**2842**	**-20**

5.3 Suitability of 'B' blocks

'B' permits to take water are traditionally issued once all 'A' permits have been taken up. They allow water to be taken during high flows and generally these takes have poor reliability and often require storage to make use of the water. Each stream in the Waimakariri Northern Tributaries area has a 'B' block. This 'B' block has an unlimited size which is not an acceptable situation to be carried into the sub-regional process.

'B' permits generally relate to high flows. Most of the waterways in the area are spring-fed and hence high flows are rare and of limited magnitude.

As such the availability of 'B' permits on these rivers presents a risk of minimising the flow variability of these rivers and also presents a very poor reliability of supply to those who take up the 'B' permits.

We have assessed the availability of 'B' blocks in the area. We have used the long term flow records available (Cam River/Ruataniwha and Cust Main Drain). These are the longest available continuous records but also represent two different types of catchments, the Cam River/Ruataniwha being spring-fed and the Cust Main Drain being hill-fed.

Given that the 'B' block is unlimited a number of example allocation limits were selected to test the reliability of the 'B' blocks.

Our analysis of the Cam River/Ruataniwha 'B' block supports the pattern of poor reliability (Table 8) expected for a spring-fed stream. Regardless of block size the days of full day restriction significantly limit the usefulness of the block.

Table 8 - Cam River/Ruataniwha 'B' block analysis

B Block test 1 1,700 L/s min flow **200 L/s** allocation limit	Full restriction	203 days
	Partial restriction	5 days
	No restriction	4 days
B Block test 2 1,700 L/s min flow **300 L/s** allocation limit	Full restriction	203 days
	Partial restriction	8 days
	No restriction	2 days
B Block test 3 1,700 L/s min flow **400 L/s** allocation limit	Full restriction	203 days
	Partial restriction	8 days
	No restriction	1 day
B Block test 4 1,700 L/s min flow **500 L/s** allocation limit	Full restriction	203 days
	Partial restriction	8 days
	No restriction	1 day

In lieu of long term data for the other spring-fed streams we have deemed the results for the Cam River/Ruataniwha to be representative of the situation on all spring-fed streams within the area. This assumption suggests that none of the spring-fed streams present viable 'B' blocks. The fact that no 'B' permits have been granted on these streams would suggest this is a reasonable assumption.

We undertook the same analysis for Cust Main Drain, which takes flow from the hill-fed Cust River. This analysis (Table 9) suggests that the 'B' block on Cust Main Drain is more viable than that of the Cam River/Ruataniwha and that it is feasible that water users could make economic use of the water.

Table 9 – Cust Main Drain ‘B’ block analysis

B Block test 1 920 L/s min flow 200 L/s allocation limit	Full restriction	112 days
	Partial restriction	25 days
	No restriction	74 days
B Block test 2 920 L/s min flow 300 L/s allocation limit	Full restriction	112 days
	Partial restriction	34 days
	No restriction	65 days
B Block test 3 920 L/s min flow 400 L/s allocation limit	Full restriction	112 days
	Partial restriction	41 days
	No restriction	58 days
B Block test 4 920 L/s min flow 500 L/s allocation limit	Full restriction	112 days
	Partial restriction	49 days
	No restriction	50 days

This analysis suggests that the ‘B’ block on Cust Main Drain is potentially viable. By extension, this would suggest that Cust River also has a potentially viable ‘B’ block given it is the source of high flows for Cust Main Drain. The upper Eyre River catchment has the same character as the Cust River and as such a ‘B’ block would also likely be viable.

There is a question around whether this water should be used if it creates addition nutrient loading issues, however this issue is not covered here and must be addressed in a wider-consideration.

5.4 Cumulative effects

The above options have been aggregated (Table 10) to form a basis for the analysis of environmental flow regime options for each SWAZ as presented in Section 6 and 7.

Three allocation summaries are presented in Table 10. These are:

- Resource Consent Inventory 1 (RCI 1) – allocation calculated as per the WRRP allocation policy
- Resource Consent Inventory 2 (RCI 2) – allocation calculated as per the WRRP allocation policy but utilising the revised SWAZ boundaries
- Resource Consent Inventory 3 (RCI 3) – allocation calculated as per the LWRP allocation policy and revised SWAZ boundaries

RCI 3 represents the what is used as a baseline for consideration of future options. The other RCI are provided here to demonstrate how these numbers were derived and through which changes differences were generated.

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Table 10 – Area wide summary

Revised SWAZ list	Stream depleting GW takes (L/s)				Surface water takes (L/s)					Allocation Limit (L/s)		Plan	Total A block allocation (L/s)			Available water (A block)					
	RCI 1: 30 day SD rates, Old SWAZ boundaries	RCI 2: 30 day SD rates, Revised SWAZ boundaries	RCI 3: 150 day SD rates, Revised SWAZ boundaries	Difference in rates (RCI 2 vs. 3)	RCI 1: Old SWAZ boundaries		RCI 2 and 3: Revised SWAZ boundaries		Difference between SWAZ boundaries (RCI 1 vs. 2/3)				RCI1: Old SWAZ + 30 day rates	RCI 2: Revised SWAZ + 30 day rates	RCI 3: Revised SWAZ + 150 day rates	RCI 1: Old SWAZ + 30 day rates		RCI 2: Revised SWAZ + 30 day rates		RCI 3: Revised SWAZ + 150 day rates	
					A	B	A	B		A	B					L/s	%			L/s	%
Silverstream	449	449	357	**-92**	92		92		**0**	1000		WRRP	541	541	449	459	46%	459	46%	551	55%
Kaiapoi River																					
Courtenay Stream	120	120	111	**-10**	37		23		**-14**	140		WRRP	157	143	134	-17	-12%	-3	-2%	6	5%
Greigs Drain					32		46		**14**	70		WRRP	32	46	46	38	54%	24	34%	24	34%
Cam River	108	108	72	**-37**	169		83		**-86**	700		WRRP	277	191	155	423	60%	509	73%	546	78%
North Brook	99	99	130	**31**	94		139		**45**	200		WRRP	193	238	269	7	4%	-38	-19%	-69	-34%
Middle Brook					29		29		**0**	30		WRRP	29	29	29	1	3%	1	3%	1	3%
South Brook	49	49	21	**-28**			60		**60**	100		WRRP	49	109	81	51	51%	-9	-9%	19	19%
Cust River	135	162	144	**-19**	265	100	265	100	**0**	290		WRRP	427	427	409	-137	-47%	-137	-47%	-119	-41%
No. 7 Drain	29	29	33	**3**	55		36		**-19**	130		WRRP	85	66	69	45	35%	64	49%	61	47%
Cust Main Drain	278	278	332	**54**	544		544		**0**	690		WRRP	822	822	876	-132	-19%	-132	-19%	-186	-27%
Ohoka Stream	464	464	438	**-27**	20		20		**0**	500		WRRP	484	484	458	16	3%	16	3%	42	8%
Upper Ohoka Stream		154	139	**-15**																	
Eyre River	543	877	1037	**160**				100	**-100**												
Upper Eyre River							67		**-67**												
Coastal Streams		32	31	**-1**																	
Saltwater Creek (Waimakariri)	*32*																				
Bennetts Creek	*27*																				
Burgess Creek	*154*																				
Waimakariri Water Race	*76*																				
Old Bed Eyre River	*258*																				
Coopers Creek					*60*				**60**												
Washpen Creek						*7*			**7**												
View Hill Creek						*100*			**100**												
Total	**2822**	**2822**	**2842**	**20**	**1604**		**1604**		**-167**	**3850**			**3097**	**3097**	**2973**						

= less than 10% water available allocated
= over allocated

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6 SWAZ specific scenarios

6.1 Introduction

Modelling scenarios are summarised below. For the Cust Main Drain and Cam River/Ruataniwha, modelling of the effects of restrictions was undertaken using flow data from long-term flow recorders. Modelling for the spring-fed streams was undertaken using data synthesised from the limited number of gauging and long records from other sites. We tested a number of scenarios (Table 11) to provide information on the viable options for future management of the surface water resource.

These scenarios are split between two categories. Scenarios 1-6 examine the effects of specific management decisions such as adopting various minimum flows, allocation limits and partial restrictions. Scenario 7 examines the effects of future changes to the available water resource on the management decisions. Climate change is not expected to materially change water resource availability in these catchments in the near term, however a number of factors relating to groundwater may impact on water availability.

The changes to water resource availability in Category 2 scenarios were taken from *'Groundwater allocation modelling results for northern Waimakariri tributaries catchment'*. The groundwater modelling work indicates a range of flow reductions in the spring-fed streams (Table 12). A threshold of 10 % has been used to determine whether the result is significant enough to undertake further assessment. In all cases we have applied the modelled change in median flow to all flows; this assumed that changes are uniform across the lower half of the flow duration curve. We have no further details to upon which to base a transient analysis.

Table 11 - Model scenario definition

Scenario 1	Represents the current consented regime
Scenario 2	Represents the WRRP regime, fully allocated
Scenario 3	Represents the WRRP regime, capped at current allocated water
Scenario 4	Represents the ecological regime (allocation and minimum flow recommendations)
Scenario 5	Represents ecological minimum flow recommendation, with WRRP allocation limit
Scenario 6	Represents cultural minimum flow recommendation, with WRRP allocation limit
Scenario 7	As per scenario 2 but with reduced flows from PC5 efficiency gains

Table 12 - Changes to water resource availability

Scenario name	Stream	Median flow decline
full_abs_allo	Cust River Cust Main Drain	36 % 14 %

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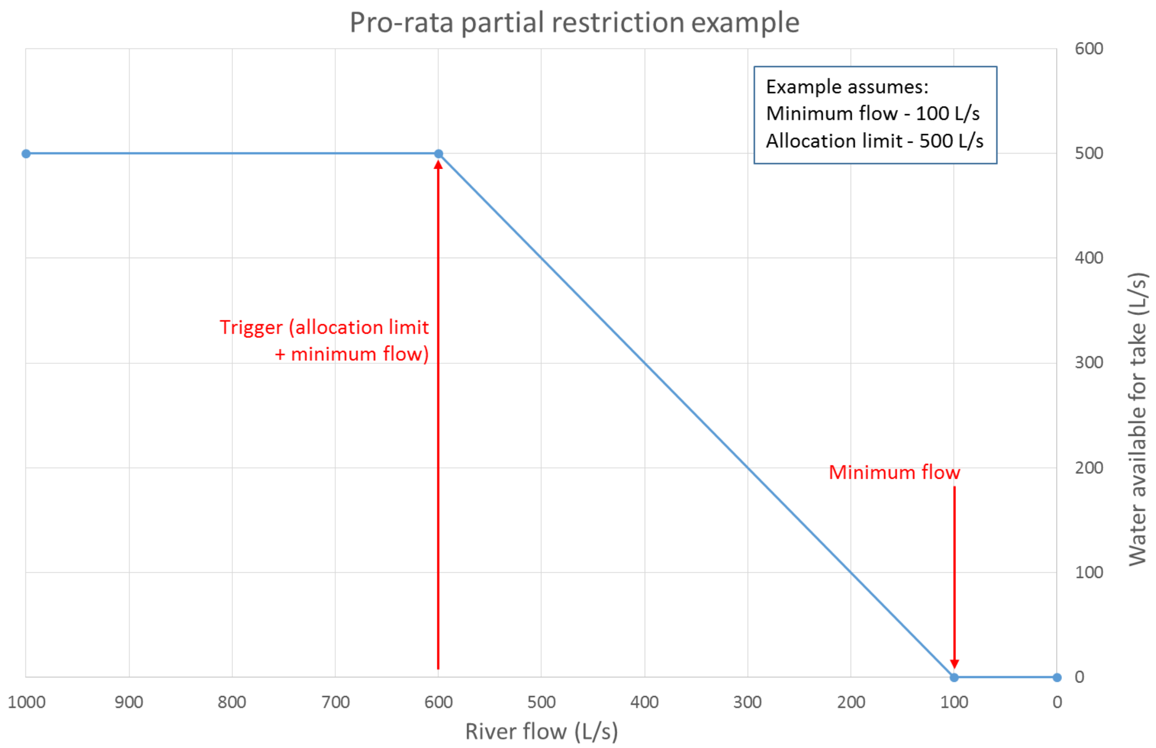
6.2 Common elements

6.2.1 Partial restrictions

For all scenario's we have used a pro-rata restriction regime. This approach ensures that the minimum flow is not breached and ensures that water remains available for use. Under this regime pro-rata restrictions commence at a river flow equal to the minimum flow plus the allocation limit. Below the trigger flow restrictions increase linearly until the minimum flow is reached and all takes must cease (Figure 1).

Due to the consent review already undertaken for the WRRP the majority of consents already have pro-rata restrictions included in their conditions. Unlike other areas this means that there is not a large step between current consent conditions and implementation of the WRRP rules.

Figure 1 – Pro-rata restriction example



6.3 Scenario table

Table 13 details the main parameters used in modelling the surface water scenarios. The parameters used to consider SWAZ created to infill current gaps are discussed in Section 7.

Table 13 – Model scenario details

		Scenario 1 - Current conditions					Scenario 2 - WRRP (Implementation)					Scenario 3 - WRRP (Cap at current use)				
River	**Site**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**
Cam	**66409**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	1700	1000	Pro-rata	700	Current	1277	1000	Pro-rata	155
North	**279**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	730	530	Pro-rata	200	Current	723	530	Pro-rata	269
Middle	**1115**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	90	60	Pro-rata	30	Current	89	60	Pro-rata	29
South	**339**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	240	140	Pro-rata	100	Current	189	140	Pro-rata	81
Cust	**270**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	310	20	Pro-rata	290	Current	620	20	Pro-rata	427
CustM	**66417**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	920	230	Pro-rata	690	Current	1052	230	Pro-rata	876
No.7	**343**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	190	60	Pro-rata	130	Current	145	60	Pro-rata	69
Ohoka	**370**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	800	300	Pro-rata	500	Current	738	300	Pro-rata	458
Silvers	**361**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	1600	600	Pro-rata	1000	Current	1134	600	Pro-rata	479
Griegs D	**371**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	220	150	Pro-rata	70	Current	182	150	Pro-rata	46
Courten	**66432**	Current	LFDB	LFDB	Pro-rata	LFDB	Current	400	260	Pro-rata	140	Current	442	260	Pro-rata	134

		Scenario 4 - Ecological (Full)					Scenario 5 - Ecological (WRRP Allo)					Scenario 6 - Cultural (WRRP Allo)				
River	**Site**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**
Cam	**66409**	Current	1200.5	890	Pro-rata	310.5	Current	1590	890	Pro-rata	700	Current	1900	1200	Pro-rata	700
North	**279**	Current	713.3	530	Pro-rata	183.3	Current	730	530	Pro-rata	200	Current	790	590	Pro-rata	200
Middle	**1115**	Current	32.5	25	Pro-rata	7.5	Current	55	25	Pro-rata	30	Current	80	50	Pro-rata	30
South	**339**	Current	186.5	140	Pro-rata	46.5	Current	240	140	Pro-rata	100	Current	270	170	Pro-rata	100
Cust	270	Current	203.7	150	Pro-rata	53.7	Current	440	150	Pro-rata	290	Current	na	na	na	na
CustM	66417	Current	320	230	Pro-rata	90	Current	920	230	Pro-rata	690	Current	1090	400	Pro-rata	690
No.7	**343**	Current	174.4	130	Pro-rata	44.4	Current	260	130	Pro-rata	130	Current	190	60	Pro-rata	130
Ohoka	**370**	Current	668.6	470	Pro-rata	198.6	Current	970	470	Pro-rata	500	Current	920	420	Pro-rata	500
Silvers	**361**	Current	1628.5	1150	Pro-rata	478.5	Current	2150	1150	Pro-rata	1000	Current	2200	1200	Pro-rata	1000
Griegs D	**371**	Current	313.4	230	Pro-rata	83.4	Current	300	230	Pro-rata	70	Current	300	230	Pro-rata	70
Courten	**66432**	Current	438	330	Pro-rata	108	Current	470	330	Pro-rata	140	Current	540	400	Pro-rata	140

		Scenario 7 - WRRP (PC5_80 Flow rates)				
River	**Site**	**Flow**	**Trigger**	**MF**	**Partial**	**Allo**
Cam	**66409**	Current	1700	1000	Pro-rata	700
North	**279**	Current	730	530	Pro-rata	200
Middle	**1115**	Current	90	60	Pro-rata	30
South	**339**	Current	240	140	Pro-rata	100
Cust	**270**	x0.64	310	20	Pro-rata	290
CustM	**66417**	x0.86	920	230	Pro-rata	690
No.7	**343**	Current	190	60	Pro-rata	130
Ohoka	**370**	Current	800	300	Pro-rata	500
Silvers	**361**	Current	1600	600	Pro-rata	1000
Griegs D	**371**	Current	220	150	Pro-rata	70
Courten	**66432**	Current	400	260	Pro-rata	140

Scenario 1	
LFDB Band used	
Cam	Band 3
North	Band 1
Middle	Band 1
South	Band A CRC180124
Cust	Band 2
CustM	Band 20
No.7	Band 1
Ohoka	Band 12
Silvers	Band 2
Griegs D	Band 2
Courten	Band 1

7 Model results

7.1 Introduction

The modelling results are presented below. There are two outputs to be interpreted (1) the effects on supply reliability, and (2) the effect on flow within the river.

For these, the key inputs are minimum flow, allocation block size and the resulting partial restriction trigger level.

1. **Minimum flow** – This is the river flow below which takes must cease (i.e full restrictions). A low minimum flow will result in a smaller number of days on full restriction, but will have poorer outcomes for the stream ecological and cultural values. A higher minimum flow will result in a greater number of days on full restriction but will have better outcomes for other values.
2. **Allocation block limit** – This is the total amount of water allowed to be taken from the surface water. A large allocation block means that flow variability will be lost from a wide range of flows, a small block means that variability will be lost from only a small range of flows, better protecting the natural function of the water way. A smaller block size generally protects users reliability whereas a large block size (on the same river) generally reduces users reliability.
3. **Partial restriction trigger** – This is the river flow below which takes start to be restricted. It is the sum of the minimum flow + allocation block limit. If either, or both, are large this results in a high partial restriction trigger. The effect of this is most of the flow occurring being under the trigger level and hence an increase to the number of days users are on partial restrictions. A lower trigger level results in less days on partial restriction. These restrictions are detrimental for users as they cannot take their full consented amount. Whilst partial restrictions are beneficial to ecological values, a high trigger risks flows flat-lining at the minimum flow. If this occurs over extended periods then the values of the river will suffer; this is more a function of the allocation block size rather than the partial restrictions.

It is important to note that the current consented situation is almost identical to the regime required in the WRRP. This is because of the consent review undertaken. The rules in the WPRP are not open for re-litigation under this current process; they can however be used to as the basis for a 'stay at current' scenario.

Only scenarios 2,3,4,6 and 7 are discussed here. All of the restriction and economic information presented in Section 7 has been taken from Harris (2018).

7.2 Cam River/Ruataniwha SWAZ

7.2.1 Reliability of supply & river flow

There is a strong alignment between current consents and the plan rules and limits. This means that the current consenting scenario generally reflects the WRRP scenario.

Under the *WRRP – full implementation* scenario there are 24 days full restrictions per year on average with much of the rest of the season on partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season if consent holders take their full entitlement.

The ecological recommendations do not alter the number of days partial restriction, however the days on full restriction decrease significantly due to the lower minimum flow. The ecological minimum flow for this site is lower than the WRRP minimum flow. This is because the WRRP minimum flow was set to provide dilution to wastewater discharges, rather than for ecological purposes.

The cultural recommendation for minimum flow increases days of full restriction significantly, but would also increase the amount of water kept in the river.

Table 13 – Cam River/Ruataniwha reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	156	24	50 %	$0.45	$6.15	$3.06	50
WRRP – Cap at current allocation	46	24	19 %	$0.28	$1.85	$0.92	15
Ecological recommendations	83	1	16 %	$0.60	$3.81	$1.90	31
Cultural recommendations with WRRP allocation limit	109	84	67 %	$0.01	$4.97	$2.47	40

Peak water use (January) was estimated as 100 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be reliable upon as it is at the discretion of the consent holder.

7.2.2 Catchment-wide approach

A catchment-wide approach should be considered for the Cam River SWAZ because the three Brooks SWAZ are also part of the overall Cam River/Ruataniwha catchment. Taking a catchment-wide approach assesses the effect management rules in the three Brooks have on the Cam River itself.

An analysis of flow records (in particular recession curves) on the Cam River/Ruataniwha and the three brooks shows that the Cam River/Ruataniwha reaches its minimum flow around

30 days before North and South Brook. Given Middle Brook's small size it has not been considered further. The effect of this inequity across minimum flows is that when the Cam River/Ruataniwha is intended to be protected from the effects of abstraction, consents on the North and South Brook continue to degrade the flow within the main stem of the Cam River/Ruataniwha.

This could be resolved by keeping the Cam River minimum flow at the WRRP level, and adjusting the North and South Brook minimum flows to align with the cultural recommendations. This is raised in the relevant sections on North Brook and South Brook.

The total allocation for the Cam River/Ruataniwha main stem is the sum of allocation on the Cam River SWAZ and the three Brooks SWAZ. This gives an allocation limit of 1030 L/s for the whole catchment. The allocation limit for Cam River/Ruataniwha main stem is 700 L/s. When assessing options for allocation in these SWAZ the cumulative effects on the Cam River/Ruataniwha should be noted. Across the four SWAZ which make up the Cam River/Ruataniwha catchment 534 L/s is currently allocated.

To manage the cumulative effects on Cam River/Ruataniwha it would be prudent to aim for ensuring that the total allocation for the catchment does not exceed the current allocation of the Cam mainstem, that being 700 L/s. Consideration should also be given to a catchment-wide allocation which equals the ecological allocation recommendations, however, whilst providing a high level of ecological protection there are potentially significant negative effects on economics which should also be considered.

7.2.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that the Cam River/Ruataniwha is insensitive to changes in groundwater recharge caused by PC5 implementation. This aligns with our conceptual understanding of the river which suggests that much of the base flow in the river is sourced from groundwater which is fed by the Ashley River/Rakahuri.

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7.3 North Brook SWAZ

7.3.1 Reliability of supply & river flow

There is a strong alignment between current consents and the plan rules and limits. This means that the current consenting scenario generally reflects the WRRP scenario.

Under the *WRRP – full implementation* scenario there are 7 days full restrictions per year on average with much of the rest of the season on partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season if consent holders take their full entitlement. Because allocation is higher than the current plan limit the days of partial restriction under the *Cap at current scenario* are greater that the *WRRP – full implementation scenario.*

The *Ecological scenario* reduces the number of days partial restriction, however they remain significant.

The Cultural scenario follows the same pattern as the others, with high partial restrictions and some days of full restriction. It has the highest number of days full restriction.

Table 14 – North Brook reliability summary

Scenario name	Average Restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	174	7	20 %	$0.36	$2.50	$1.23	20
WRRP – Cap at current allocation	205	7	37 %	$0.32	$2.89	$1.43	23
Ecological recommendations	139	7	16 %	$0.36	$2.37	$1.17	19
Cultural recommendations, with WRRP allocation limit	199	13	44 %	$0.18	$1.99	$0.98	16

Peak water use (January) was estimated as 100 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be reliable upon as robust management option.

7.3.2 Catchment-wide approach

As described above, North Brook reaches its minimum flow around 30 days after Cam River/Ruataniwha causing abstraction of Cam River/Ruataniwha flow below the minimum flow. This could be resolved by adopting the North Brook cultural minimum flow, however as Table x shows there is a reasonable economic implication of doing so.

North Brook currently has 279 L/s of allocation, which contributes 27 % to the total Cam River catchment allocation of 1030 L/s

To manage the cumulative effects on Cam River/Ruataniwha it would be prudent to aim for ensuring that the total allocation for the catchment does not exceed the current allocation of the Cam mainstem, that being 700 L/s. Ensuring that the allocation in Cam River is not exceeded would require the North Brook allocation being capped at or near current allocation. Further consideration should be given to the feasibility of managing allocation to the ecological recommendation, although it is recognised that the economic impacts are greater than for other allocation outcomes.

7.3.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that the North Brook is insensitive to changes in groundwater recharge caused by PC5 implementation. This aligns with our conceptual understanding of the river which suggests that much of the base flow in the river is sourced from groundwater which is fed by the Ashley River/Rakahuri.

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7.4 Middle Brook SWAZ

7.4.1 Reliability of supply & river flow

There is a strong alignment between current consents and the plan rules and limits. This means that the current consenting scenario should reflect the WRRP scenario. The modelling results do not show days of partial restriction. It is not clear why this is.

Under the *WRRP – full implementation* scenario there are 94 days full restrictions per year on average with 42 days of partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season if consent holders take their full entitlement.

It should be noted that our understanding of the flow regime in Middle Brook is particularly poor and hence this outcome should be treated with caution.

The *capped at current* scenario is essentially the same as the *WRRP – fully implemented* scenario given that the SWAZ is almost fully allocated.

The *Ecological scenario* has a very small allocation and lower minimum flow there appear to provide reliability improvements. This improved reliability would however only be available to a very small number of abstractors.

The cultural recommendation for minimum flow reduces the days of full restriction slightly, due to a slightly lower minimum flow than under the WRRP.

Table 15 – Middle Brook reliability summary

Scenario name	Average Restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	42	94	52 %	$0.02	$0.27	$0.13	2
WRRP – Cap at current allocation	40	94	52 %	$0.02	$0.26	$0.13	2
Ecological recommendations	21	14	13 %	$0.01	$0.10	$0.05	1
Cultural recommendations, with WRRP allocation limit	47	77	46 %	$0.03	$0.28	$0.14	2

A peak water use estimate is not available for Middle Brook. Anecdotal evidence suggests the single consent on the brook is not currently used.

7.4.2 Catchment-wide approach

A catchment-wide approach needs to be considered for the Middle Brook SWAZ, being part of the overall Cam River/Ruataniwha catchment. Taking a catchment-wide approach assesses the effect of management rules in Middle Brook on the Cam River/Ruataniwha itself.

That said, the current allocation on Middle Brook (29 L/s) represents 3 % of the total catchment allocation and therefore any management changes will have minimal effects on the catchment as a whole. Given Middle Brook's very small contribution to the wider catchment we have not considered whether minimum flow need to change here.

To manage the cumulative effects on Cam River/Ruataniwha it would be prudent to aim for ensuring that the total allocation for the catchment does not exceed the current allocation of the Cam mainstem, that being 700 L/s. Capping Middle Brook SWAZ allocation at current levels would support this goal if it were to be pursued.

7.4.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that the Middle Brook is insensitive to changes in groundwater recharge caused by PC5 implementation. This aligns with our conceptual understanding of the river which suggests that much of the base flow in the river is sourced from groundwater which is fed in part by the Ashley River/Rakahuri and from land surface recharge in areas which are not intensively irrigated at present.

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7.5 South Brook SWAZ

7.5.1 Reliability of supply & river flow

There is a strong alignment between current consents and the plan rules and limits. This means that the current consenting scenario reflects the WRRP-full implementation scenario.

Under the *WRRP – full implementation* scenario there are 10 days full restrictions per year on average with 112 days of partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season if consent holders take their full entitlement.

The *capped at current* scenario reduces the number of days partial restriction compared to full implementation, given that the block is currently under-allocated.

The *Ecological scenario* has a very small allocation hence partial restrictions would be reduced further.

The cultural recommendation for minimum flow increases the days of full restriction.

Table 16 – South Brook reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	112	10	22 %	$0.55	$1.81	$0.99	21
WRRP – Cap at current allocation	77	10	16 %	$0.51	$1.54	$0.84	18
Ecological recommendations	30	10	9 %	$0.34	$0.94	$0.51	11
Cultural recommendations with WRRP allocation limit	134	24	38 %	$0.31	$1.55	$0.84	18

Peak water use (January) was estimated as 100 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be relied upon as robust management option.

7.5.2 Catchment-wide approach

As described above, South Brook reaches its minimum flow around 30 days after Cam River/Ruataniwha causing abstraction of Cam River/Ruataniwha flow below the minimum flow. This could be resolved by adopting the South Brook cultural minimum flow, however there is a reasonable economic implication of doing so.

South Brook is currently has 81 L/s of allocation, which contributes 8 % to the total Cam River catchment allocation of 1030 L/s

To manage the cumulative effects on Cam River/Ruataniwha it would be prudent to aim for ensuring that the total allocation for the catchment does not exceed the current allocation of the Cam mainstem, that being 700 L/s. Ensuring that the allocation in Cam River is not exceeded would require the South Brook allocation being capped at or near current allocation.

7.5.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that the South Brook is insensitive to changes in groundwater recharge caused by PC5 implementation. This aligns with our conceptual understanding of the river which suggests that much of the base flow in the river is sourced from groundwater which is fed by the Ashley River/Rakahuri and from land surface recharge in areas which are not intensively irrigated at present.

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7.6 Cust River SWAZ

7.6.1 Reliability of supply & river flow

There is a strong alignment between current consents and the plan rules and limits. This means that the current consenting scenario generally reflects the WRRP scenario, albiet with a lower partial restriction trigger which reflects the under-allocated status of the watercourse.

Under the WRRP – full implementation scenario there are 3 days full restrictions per year on average with much of the rest of the season (73 days) on partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season if consent holders take their full entitlement.

Because allocation is lower than the current plan limit the days of partial restriction under the Cap at current scenario are lower that the WRRP – full implementation scenario.

The Ecological scenario reduces the number of days partial restriction, but increases the number of days full restriction. This is because the allocation is smaller, but the minimum flow higher.

The Cultural scenario was not modelled as no cultural recommendations were provided for this site in the COMAR.

Table 17 – Cust River reliability summary

Scenario name	Average Restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	73	3	14 %	$0.47	$3.18	$1.57	25
WRRP – Cap at current allocation	122	3	24 %	$0.58	$4.34	$2.14	34
Ecological recommendations	15	27	15 %	$0.09	$0.59	$0.29	5
Cultural recommendations, with WRRP allocation limit	-	-	-	-	-	-	-

Peak water use (January) was estimated as 100 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be relied upon as robust management option.

7.6.2 Catchment-wide approach

A catchment-wide approach needs to be considered for the Cust River SWAZ because, along with Cust Main Drain SWAZ and No.7 Drain SWAZ they form the wider Cust River catchment. Taking a catchment-wide approach assesses the effect management rules in each SWAZ have on the Cust River catchment. This is less important for the Cust River, as in times of low flow the Cust River is not directly connected to the lower catchment (it does however provide recharge to Cust Main Drain via groundwater).

An analysis of flow records (in particular recession curves) on the Cust River shows that it reaches its minimum flow around 50 days before Cust Main Drain and No.7 Drain. This makes sense given it is a hill-fed catchment when the others are primarily spring-fed.

It is not considered necessary to investigate what would be required to align the minimum flow of the Cust River SWAZ with the rest of the catchment given the disconnection at low flows. This is also the case with allocation, given the Cust River surface water resource is not directly connected to the Cust Main Drain resource.

7.6.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that Cust River is sensitive to changes in groundwater recharge caused by PC5 implementation. Our predictions are that low flows could reduce by 36 % from the current level. Under the existing WRRP framework this would see the number of days full restriction increase to 12 days and the volume restriction become 47%. This would suggest that in would be unwise to plan for the Cust River abstraction regime to operate near its current limits as that would leave the environment and abstractors exposed to reducing water availability.

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7.7 Cust Main Drain SWAZ

7.7.1 Reliability of supply & river flow

'Current consents' (not reported here) and WRRP full implementation are effectively the same scenario given the strong alignment between consents and the plan rules and limits. Under this scenario there are 12 days full restrictions per year on average with part of the rest of the season on partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season if consent holders take their available water.

Capping allocation at current allocated water makes the partial restriction situation slightly worse, because the catchment is currently over-allocated. Capping at current therefore increases the restriction trigger level.

The ecological scenario results in no change to full days restriction, because the minimum flow does not change. Days partial restriction are significantly reduced, the driver for this being a significantly smaller ecological allocation.

It should be noted that when we naturalise the flow series of Cust Main Drain for groundwater effects (abstractions and recharge from WIL) the baseflow in the stream is reduced by 50 %. Naturalised flows are used to develop minimum flow and allocation estimates for the ecological scenario. Whilst we are uncertain about the scale of this reduction we believe the indication of flow decline it provides is deemed correct as it mirrors conditions pre- and post-WIL.

By analysing Cust Main Drain flow records for the periods before and after WIL commissioning a step increase in flow can be seen following WIL commencing operation and this supports a reduction in flow if the effects of WIL we removed.

The absolute numbers associated with the ecological scenario should be used as recommended environmental flow regime with caution, it is however a very important indicator as to the future availability of water and the risks attached to that water. At a basic level this work suggests that adopting an environment flow regime which operate at the upper boundary of the currently available water resource would expose water users to a high degree of risk.

The cultural recommendation causes a higher number of days on full restriction.

Table 18 – Cust Main Drain reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	124	12	30 %	$0.95	$7.61	$3.72	58
WRRP – Cap at current allocation	144	12	37 %	$1.01	$9.08	$4.43	69
Ecological recommendations	45	12	86 %	$0.17	$1.14	$0.55	9
Cultural recommendations, with WRRP allocation limit	119	36	14 %	$0.66	$6.74	$3.29	51

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Peak water use (January) was estimated as 79 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be relied upon as robust management option.

7.7.2 Catchment-wide approach

As discussed above there is little to be gained in attempting further alignment of minimum flows between No.7 Drain and Cust Main Drain.

The combined allocation limit for Cust Main Drain and No.7 Drain is 820 L/s. Current allocation exceeds this value on Cust Main Drain alone, and hence consideration should be given to managing allocation jointly between these catchments to achieve outcomes.

7.7.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that Cust Main Drain is sensitive to changes in groundwater recharge caused by PC5 implementation. Our predictions are that low flows could reduce by 14 % from the current level. Under the existing WRRP framework this would see the number of days full restriction increase from 12 days to 185 days and the volume restriction become 85 %. This indicates that there is a potentially significant water resource availability issue on Cust Main Drain and this warrants further investigation to support the validity of long-term management decisions here.

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7.7.4 No.7 Drain SWAZ

7.7.5 Reliability of supply & river flow

There is a reasonable alignment between current consents and the plan rules and limits, although minimum flows vary across the current banding system. This means that the current consenting scenario does not fully y reflect the WRRP scenario.

Under the *WRRP – full implementation* scenario there are 182 days partial restrictions per year on average with 18 days full restrictions. This has the potential effect of holding the river at or around the minimum flow for the whole irrigation season if consent holders take their full entitlement.

Because allocation is lower than the current plan limit the days of partial restriction under the *Cap at current* scenario are somewhat lower that *the WRRP – full implementation* scenario but still significant.

The Ecological scenario contains a minimum flow over 100 % higher than current, which causes the majority of the season to be under full restrictions.

The Cultural scenario was the same as *WRRP – fully implemented.*

Table 19 – No. 7 Drain reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	182	18	62 %	$0.04	$1.03	$0.50	8
WRRP – Cap at current allocation	155	18	46 %	$0.06	$0.65	$0.32	5
Ecological recommendations	20	175	78 %	-$0.01	$0.28	$0.14	2
Cultural recommendations, with WRRP allocation limit	182	18	62 %	$0.04	$1.03	$0.50	8

An estimate of peak water use was not available.

7.7.6 Catchment-wide approach

An analysis of flow records (in particular recession curves) on No. 7 Drain shows that it reaches its minimum flow within 7 days of Cust Main Drain, hence they are already relatively well aligned and this should be maintained where possible. The level of accuracy associated with the analysis/base data does not warrant further fine-tuning of these minimum flows.

The combined allocation limit for Cust Main Drain and No.7 Drain is 820 L/s. Current allocation exceeds this value on Cust Main Drain alone, and hence consideration should be given to managing allocation jointly between these catchments.

7.7.7 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that No.7 Drain is insensitive to changes in groundwater recharge caused by PC5 implementation.

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7.8 Ohoka Stream SWAZ

7.8.1 Reliability of supply & river flow

'Current consents' (not reported here) and WRRP full implementation are effectively the same scenario given the strong alignment between consents and the plan rules and limits. There is a small difference in days partial restriction because the block is not full allocated at present.

Under the WRRP scenario there are 0 days full restrictions per year on average with most of the rest of the season on partial restrictions. This has the effect of holding the river at or around the minimum flow for much of the irrigation season.

Capping allocation at current allocated water makes the partial restriction situation slightly better that the WRRP scenario, because it would limit the effects of further abstraction.

The ecological scenario results in significant days of full restriction occurring because of the higher minimum flow; this pattern is reflected in the Cultural scenario albeit to a lesser extent.

Table 20 – Ohoka Stream reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	191	0	28 %	$0.64	$4.29	$2.11	36
WRRP – Cap at current allocation	185	0	24 %	$0.63	$4.05	$2.00	34
Ecological recommendations	98	58	30 %	$0.24	$1.67	$0.82	14
Cultural recommendations, with WRRP allocation limit	171	33	46 %	$0.39	$3.62	$1.78	30

Peak water use (January) was estimated as 57 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be relied upon as robust management option.

7.8.2 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that Ohoka Stream is insensitive to changes in groundwater recharge caused by PC5 implementation.

7.9 Kaiapoi River SWAZ

7.9.1 Reliability of supply & river flow

'Current consents' (not reported here) and WRRP full implementation are effectively the same scenario given the strong alignment between consents and the plan rules and limits. There is a 50% difference in days partial restriction because the block is not full allocated at present (approximately 50 % allocated). Under the WRRP scenario there are 0 days full restrictions per year on average with 55 days on partial restrictions.

Capping allocation at current allocated water makes the partial restriction situation better (21 days) than the WRRP scenario, because it would limit the effects of further abstraction.

The ecological scenario results in significant days of full restriction occurring because of the higher minimum flow; this pattern is reflected in the Cultural scenario albeit to a much greater extent in the number of days partial restrictions occur. This is because the higher minimum flow pushes up the restriction trigger.

Table 21 – Kaiapoi River reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	55	0	6 %	$2.39	$16.25	$7.87	117
WRRP – Cap at current allocation	21	0	2 %	$1.27	$8.18	$3.96	59
Ecological recommendations	34	27	11 %	$1.00	$7.33	$3.55	53
Cultural recommendations with WRRP allocation limit	139	30	23 %	$1.38	$13.06	$6.32	94

Peak water use (January) was estimated as 80 % of the available water, this is likely to tail off in the months either side of the peak. This means that some flow variability in the non-peak months may exist when users are not taking their full allocation, however this cannot be relied upon as robust management option.

7.9.2 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that Kaiapoi River is insensitive to changes in groundwater recharge caused by PC5 implementation.

7.10 Courtenay Stream SWAZ

7.10.1 Reliability of supply & river flow

There is a strong alignment between current consents and the plan rules and limits. This means that the current consenting scenario should reflect the WRRP scenario. The Current consenting modelling results do not show days of partial restriction. It is not clear why this is.

Under the WRRP-full implementation scenario there are 0 days full restrictions per year on average.

Capping allocation at current allocated water keeps full days restriction at 0 days.

The ecological scenario results in a change to restrictions. 15 days full restriction are created and the volume restriction is doubled. The cultural scenario increases restrictions further.

Table 22 – Courtenay Stream reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	64	0	9 %	$0.32	$2.08	$1.01	15
WRRP – Cap at current allocation	60	0	8 %	$0.31	$2.00	$0.97	15
Ecological recommendations	73	15	22 %	$0.20	$1.45	$0.70	11
Cultural recommendations with WRRP allocation limit	73	64	43%	$0.14	$1.55	$0.75	11

An estimate of peak water use was not available.

7.10.2 Catchment-wide approach

A catchment-wide approach needs to be considered for Courtenay Stream SWAZ because, along with Greigs Drain SWAZ, they form the wider Courtenay Stream catchment. Taking a catchment-wide approach assesses the effect management rules in each SWAZ have on the Courtenay Stream itself.

An analysis of flow records (in particular recession curves) on Courtenay Stream could not identify any minimum flow offset with Greigs Drain because neither site reaches its minimum flow. Using the ecological minimum flows instead it is evident that Courtenay Stream reaches its that minimum flow 10-14 days before Greigs Drain. This means that under the ecological minimum flow regime Courtenay Stream would be degraded by abstractions on Greigs Drain despite the minimum flow being reached. This would not occur under the current minimum flow arrangement.

The combined allocation limit for Courtenay Stream and Greigs Drain is 210 L/s. Current combined allocation is 180 L/s. If allocation was capped at this figure then Courtenay Stream would be 30 % over-allocated, the limit being 140 L/s. Consideration should be given to managing allocation jointly between these catchments.

7.10.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that Courtenay Stream is insensitive to changes in groundwater recharge caused by PC5 implementation.

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7.11 Greigs Drain SWAZ

7.11.1 Reliability of supply & river flow

‘Current consents’ (not reported here) and WRRP full implementation are effectively the same scenario given the strong alignment between consents and the plan rules and limits. No days of full restriction occur under either scenario.

Capping allocation at current allocated water keeps full days restriction at 0 days.

The ecological scenario results in a small change to restrictions. 3 days full restriction are created and the volume restriction increases to 12 %. The cultural scenario is very similar.

Table 23 – Greigs Drain reliability summary

Scenario name	Average restrictions			Regional economic outcomes			
	Partial days	Full days	% Vol	Operating profit ($M/yr)	Regional GDP ($M/yr)	Regional Household Income ($M/yr)	Regional Employment (FTE)
WRRP – Full implementation	1	0	0 %	$0.17	$0.98	$0.48	7
WRRP – Cap at current allocation	0	0	0 %	$0.11	$0.64	$0.31	5
Ecological recommendations	53	3	12 %	$0.17	$1.08	$0.53	8
Cultural recommendations with WRRP allocation limit	43	3	10 %	$0.15	$0.92	$0.45	7

An estimate of peak water use was not available.

7.11.2 Catchment-wide approach

A catchment-wide approach needs to be considered for Greigs Drain SWAZ because, along with Courtenay Stream SWAZ, they form the wider Courtenay Stream catchment. Taking a catchment-wide approach assesses the effect of management rules in each SWAZ have on the Courtenay Stream itself.

An analysis of flow records (in particular recession curves) on Courtenay Stream could not identify any minimum flow offset with Greigs Drain because neither site reaches its minimum flow. Using the ecological minimum flows instead it is evident that Courtenay Stream reaches its minimum flow 10-14 days before Greigs Drain. This means that under the ecological minimum flow regime Courtenay Stream would be degraded by abstractions on Greigs Drain despite the minimum flow being reached. This would not occur under the current minimum flow arrangement.

The minimum flow in Greigs Drain would need to be increased to 250 L/s to align the catchments flow management regimes.

The combined allocation limit for Courtenay Stream and Greigs Drain is 210 L/s. Current combined allocation is 180 L/s. If allocation was capped at this figure then Courtenay Stream would be 30 % over-allocated. Consideration should be given to managing allocation jointly between these catchments.

7.11.3 Effects of changing water resource

The assessment of effects on river flow as a result of full use of the full groundwater allocation, showed that Courtenay Stream is insensitive to changes in groundwater recharge caused by PC5 implementation.

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7.12 Current gaps

The current SWAZ layout in the WRRP (Figure 2) does not include the entire WWZ. Current and potential water users in the areas not covered by SWAZ are therefore exposed to uncertainty regarding the available water.

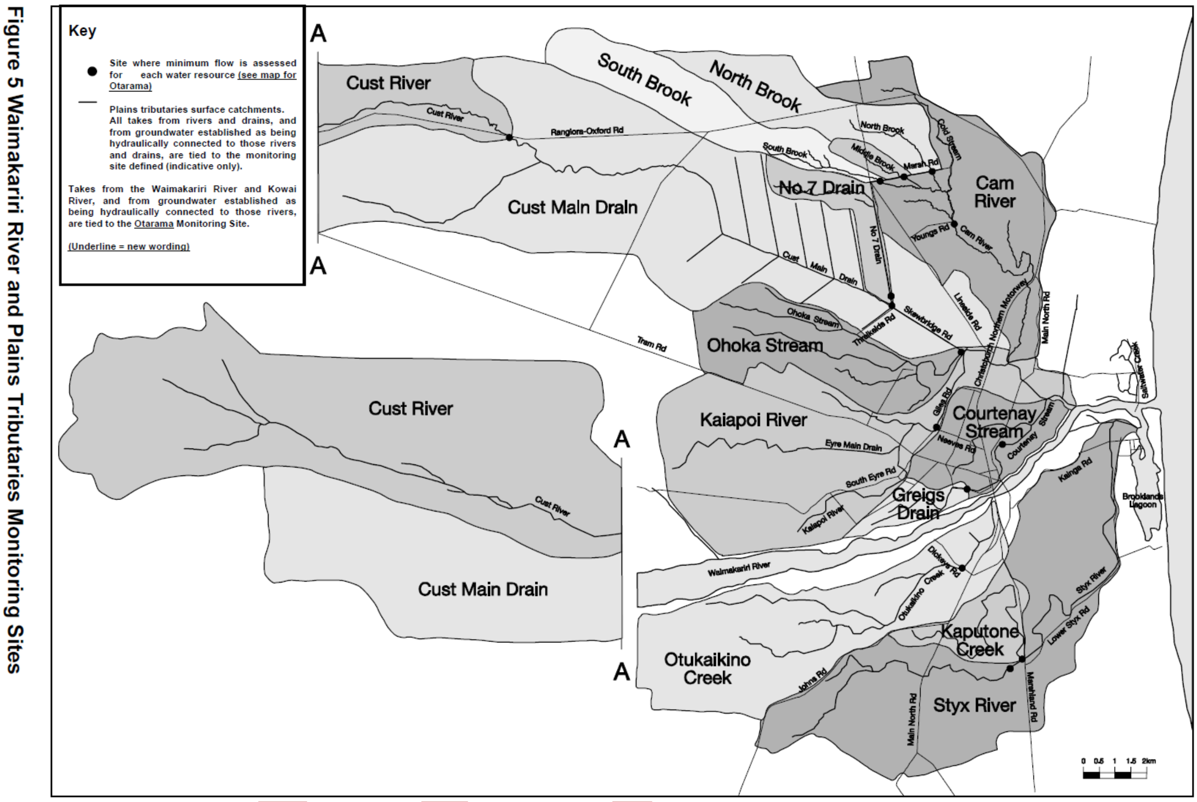

Figure 2 – WRRP SWAZ map

Provided below is a summary of the water management options available to provide certainty in the current non-SWAZ areas. This is based on creating a number of new SWAZ to ensure no gaps exist.

7.12.1 Upper Eyre River SWAZ

The Upper Eyre River SWAZ covers the hill-catchment of the Eyre River and the upper extents of the plains west of the Waimakariri Irrigation Limited main race. This catchment is dominated by low baseflows, interspersed with flood flows from the hillslopes of Mt Oxford. Currently a maximum of 83 L/s is allocated in the A block and 6.5 L/s is allocated to the B block.

The 'A' block comprises two consents held by Waimakariri District Council for community supply purposes. CRC990931.1 is one of the A permits and had a maximum rate which varies by month, and has different rates if the other A permit (CRC166592) is also being used. Permits granted for community water supply do not need to respond to minimum flow requirements in the same way as irrigation takes, never the less minimum flows for such takes can be a useful indication for when water saving initiatives are required to conserve water. The A permits currently have no minimum flow conditions.

A single 'B' permit is granted, this is for private irrigation purposes and has a minimum flow site where Island Road crosses Mounseys Stream.

Establishing a minimum flow sites which covers all of the current and potential future abstraction points will be problematic here, given the diversity of tributaries from which takes occur.

7.12.2 Eyre River SWAZ

The Eyre River SWAZ forms a large part of the Zone, yet currently there in not a SWAZ which covers the area and no allocation limits are set. 1037 L/s of surface water is allocated in this area.

The surface hydrology of the area is dominated by a large water race network which dissects the natural flow patterns into small units. Given the highly permeable nature of the gravels in this area it is unlikely that any substantial perennial surface features existed. The only significant stream in the area is the Eyre River itself which goes dry around Oxford and rarely holds a continuous flow. All of the water allocated is deemed to be stream-depleting, despite the fact there are few, if any, perennial streams to deplete.

Minimum flow restrictions are not frequently applied given the lack of perennial stream on which to base such a restriction. Some consents have a level based restriction system, relating to a monitoring well.

There is insufficient data available to assess flows within surface features and the reliability of supply from them. Given that little minimum flow or partial restrictions current apply to takes it can be assumed that reliability of supply is not an issue for the takes present, unless groundwater levels fall below pump intake levels. Reliability will be further complicated given many users in this area will also have supply arrangements with Waimakariri Irrigation Limited for Waimakariri River water.

7.12.3 Coastal Streams SWAZ

This SWAZ covers a discrete area bounded to the north by the catchment watershed (just south of Tūtaepatu Lagoon), to the south by the Waimakariri River, to the west by Kaiapoi, SH1 and Woodend and to the east by the coast.

Kairaki Creek and Macintosh Drain are the named streams in this area. They flow from north to south and both enter the Waimakariri River directly, either side of Kaiapoi Waste Water Treatment Plant.

There is currently 31 L/s of water consented to be taken from this area. All water currently consented is via stream-depleting groundwater takes.

The current consents do not contain minimum flow conditions, and currently there is no minimum flow site which can be used to manage water in this area. These streams sit within an inter-dune area which is different from areas already covered by minimum flow sites. Therefore if these streams were to be managed by way of minimum flow a new site would need to be established. This will be problematic given the slack water present and extensive weed growth.

There is insufficient data available to assess flows within these streams and the reliability of supply from them. Given that no minimum flow or partial restrictions current apply to takes it can be assumed that reliability of supply is not an issue for the small takes present.

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8 Management options

The outcome of this memorandum is the presentation below of options for the management of the Northern Waimakariri tributaries.

SWAZ	Issue	Options
SD30 - 150	Inconsistency with regional rules	• Retain WRRP stream depletion rules (30 day) • Move to WRRP stream depletion rules (150 day)
SWAZ	Incorrect boundaries. Areas not covered by SWAZ	• Retain WRRP SWAZ boundaries • Move to revised boundaries • Infill areas currently without SWAZ
B Blocks	Very poor reliability for B block in spring-fed streams Risk of reducing reliability for existing users if further permits are granted Potentially significant impacts on flow regime in spring-fed streams	• Retain 'B' blocks on spring-fed streams • Remove 'B' blocks on spring-fed streams • Cap existing 'B' blocks at current allocation (and/or + headroom)

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SWAZ	Issue	Options
Cam River/ Ruataniwha	Water abstraction, along with other pressures, is impacting upon the values of the waterway	• Minimum flow is left at WRRP flow of 1,000 L/s • Minimum flow is changed to ecological recommendation of 890 L/s • Minimum flow is changed to ecological recommendation of 1,200 L/s • Minimum Flow is set in the context of the wider Cam River catchment (Cam + 3 Brooks) • Allocation limit is capped at current allocation (155 L/s) • Allocation limit is left at the WRRP limit (700 L/s) • Allocation limit changed to the ecological recommendation (311 L/s) • Allocation limit is set in the context of the wider Cam River catchment (Cam + 3 Brooks)
Northbrook	Water abstraction, along with other pressures, is impacting upon the values of the waterway	• Minimum flow is left at WRRP flow of 530 L/s (This is also the ecological recommendation) • Minimum flow is changed to ecological recommendation of 590 L/s • Minimum flow is set in the context of the wider Cam River catchment (Cam + 3 Brooks) • Allocation limit is capped at current allocation (269 L/s) • Allocation limit is left at the WRRP limit (200 L/s) • Allocation limit changed to the ecological recommendation (183 L/s) • Allocation limit is set in the context of the wider Cam River catchment (Cam + 3 Brooks)
Middlebrook	Water abstraction, along with other	• Minimum flow is left at WRRP flow of 60 L/s

SWAZ	Issue	Options
	pressures, is impacting upon the values of the waterway. Leaving a large allocation available on such a small waterbody risks a water take regime with significant effects on the ecology of the waterway and which cannot support reliable irrigation.	• Minimum flow is changed to ecological recommendation of 25 L/s • Minimum flow is changed to ecological recommendation of 50 L/s • Minimum Flow is set in the context of the wider Cam River catchment (Cam + 3 Brooks) • Allocation limit is capped at current allocation (29 L/s) • Allocation limit is left at the WRRP limit (30 L/s) • Allocation limit changed to the ecological recommendation (8 L/s) • Allocation limit is set in the context of the wider Cam River catchment (Cam + 3 Brooks)
Southbrook	Water abstraction, along with other pressures, is impacting upon the values of the waterway	• Minimum flow is left at WRRP flow of 140 L/s (This is also the ecological recommendation) • Minimum flow is changed to cultural recommendation of 170 L/s • Minimum Flow is set in the context of the wider Cam River catchment (Cam + 3 Brooks) • Allocation limit is capped at current allocation (100 L/s) • Allocation limit is left at the WRRP limit (81 L/s) • Allocation limit changed to the ecological recommendation (47 L/s) • Allocation limit is set in the context of the wider Cam River catchment (Cam + 3 Brooks)
Cust River		• Minimum flow is left at WRRP flow of 20 L/s • Minimum flow is changed to ecological & cultural recommendation of 150 L/s • Minimum Flow is set in the context of the wider Cust River catchment (Cust, CMD, No.7) • Allocation limit is capped at current allocation (427 L/s) • Allocation limit is left at the WRRP limit (290 L/s) • Allocation limit changed to the ecological recommendation (54 L/s) • Allocation limit is set in the context of the wider Cust River catchment (Cust + CMD, No.7)
Cust Main Drain		• Minimum flow is left at WRRP flow of 230 L/s • Minimum flow is changed to ecological recommendation of 270 L/s

SWAZ	Issue	Options
		• Minimum flow is changed to cultural recommendation of 400 L/s • Minimum Flow is set in the context of the wider Cust River catchment (Cust, CMD, No.7) • Allocation limit is capped at current allocation (876 L/s) • Allocation limit is left at the WRRP limit (690 L/s) • Allocation limit changed to the ecological recommendation (90 L/s) • Allocation limit is set in the context of the wider Cust River catchment (Cust, CMD, No.7)
No.7 Drain		• Minimum flow is left at WRRP flow of 60 L/s (This is also the cultural recommendation) • Minimum flow is changed to ecological recommendation of 130 L/s • Minimum Flow is set in the context of the wider Cust River catchment (Cust, CMD, No.7) • Allocation limit is capped at current allocation (69 L/s) • Allocation limit is left at the WRRP limit (130 L/s) • Allocation limit changed to the ecological recommendation (44 L/s) • Allocation limit is set in the context of the wider Cust River catchment (Cust, CMD, No.7)
Ohoka Stream		• Minimum flow is left at WRRP flow of 300 L/s • Minimum flow is changed to ecological recommendation of 470 L/s • Minimum flow is changed to cultural recommendation of 420 L/s • Allocation limit is capped at current allocation (458 L/s) • Allocation limit is left at the WRRP limit (500 L/s) • Allocation limit changed to the ecological recommendation (199 L/s)
Kaiapoi River		• Minimum flow is left at WRRP flow of 600 L/s • Minimum flow is changed to ecological recommendation of 1150 L/s • Minimum flow is changed to cultural recommendation of 1200 L/s

SWAZ	Issue	Options
		• Allocation limit is capped at current allocation (449 L/s) • Allocation limit is left at the WRRP limit (1000 L/s) • Allocation limit changed to the ecological recommendation (479 L/s) •
Courtenay Stream		• Minimum flow is left at WRRP flow of 260 L/s • Minimum flow is changed to ecological recommendation of 330 L/s • Minimum flow is changed to cultural recommendation of 400 L/s • Minimum flow set in the context of the wider Courtenay Stream catchment (Courtenay + Greigs) • Allocation limit is capped at current allocation (134 L/s) • Allocation limit is left at the WRRP limit (140 L/s) • Allocation limit changed to the ecological recommendation (108 L/s) • Allocation limit set in the context of the wider Courtenay Stream catchment (Courtenay + Greigs)
Greigs Drain		• Minimum flow is left at WRRP flow of 150 L/s • Minimum flow is changed to ecological / cultural recommendation of 230 L/s • Minimum flow set in the context of the wider Courtenay Stream catchment (Courtenay + Greigs) • Allocation limit is capped at current allocation (24 L/s) • Allocation limit is left at the WRRP limit (70 L/s) • Allocation limit changed to the ecological recommendation (83 L/s) • Allocation limit set in the context of the wider Courtenay Stream catchment (Courtenay + Greigs)
Upper Eyre River	No limits currently set	• Minimum flow is assigned on consent by consent basis. • WRRP minimum flow site is established

SWAZ	Issue	Options
		• Minimum flow set using default LWRP rule • A and B allocation limits are capped at current • A and B allocation limits are capped at current + headroom (size tbc)
Eyre River	No limits currently set	• All takes in area assigned to GAZ. SWAZ allocation limit set to 0 L/s • Any consents deemed to stream deplete streams outside the Eyre River SWAZ assigned to that stream under its limits and minimum flows. • Set SWAZ allocation limit using cap at current approach • Set Minimum Flow to 0 L/s
Coastal Streams	No limits currently set	• All takes in area assigned to GAZ. SWAZ allocation limit set to 0 L/s • Any consents deemed to stream deplete streams outside the Eyre River SWAZ assigned to that stream under its limits and minimum flows. • Set SWAZ allocation limit using cap at current approach • Set Minimum Flow to 0 L/s

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8.1 Additional management strategies

The over-allocation issues evident in these catchments mean that a large degree of effort will be required to manage abstractions back to the current allocation limits. Reduction of allocation limits further, towards the ecological recommendations for instance, will require extensive mitigation work to be undertaken, most likely resulting in the need for consents to be surrendered.

Provided below is a list of alternative strategies for recovering the over-allocation and taking smaller reductions in the allocated water should this de deemed appropriate.

An alternative management strategy is to accept an environmental flow and allocation regime which does not itself meet all of the values being sought and back this up with physical mitigation techniques which increase the efficacy of the environmental flow and allocation regime. Example of these techniques are also provided.

Mitigation	Justification
Revised stream depletion assessment	Stream depletion estimates used in the development of allocation limits is conservative. Site specific assessments, or use of another accepted methodology, could reduce the paper over-allocation
Consider municipal supplies differently	Some allocation blocks (Taranaki, Saltwater, Ashely River) include municipal supply water. This water is not subject to minimum flow restrictions in the same way as irrigation consents. Additionally some municipal takes as back-ups only and so are not used on a regular basis.
Voluntary surrender	If low use/no use consents which contribute to over-allocation we surrendered this would take catchments closer to the agreed allocation limits
% reductions of water use at consent renewal/review	When consents are renewed/reviewed the actual water use can be examined and the consented amount can be reduced should it be found water is not being used. Under a falling lid situation this water would stay in the river and not be reallocated.
Switch to deep groundwater	Deep groundwater could provide an alternative source of supply for some users thereby reducing the water allocated/used in catchment, leaving more in the waterways
Restrict transfers	Restricting transfer of water between properties can result in less water being used, and ultimately consents being surrendered. If transfers are deemed appropriate then it is also possible to require that a % of any transferred water be returned to the river and not reallocated.
Offset mitigation	Planting for shading and habitat purposes, and installation of riffles can improve the outcomes of environmental flow and allocation regimes. This can reduce water temperature and increase dissolved oxygen levels which can reduce the overall ecological stress of low water levels.

9 References

- Harris (2018) Waimakariri Land and water solutions programme: Economic assessment of the impacts of changes in flow and N management in the Northern Waimakariri Tributaries
- Land and Water Regional Plan
- National Policy Statement for Freshwater Management 2014, Updated August 2017 to incorporate amendments from the National Policy Statement for Freshwater Amendment Order 2017
- Waimakariri River Regional Plan

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Appendix A | SWAZ maps

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Appendix 1 maps:

- Overview
- Cam River / Ruataniwha
- North Brook
- Middle Brook
- South Brook
- Cust River
- Cust Main Drain
- No. 7 Drain
- Ohoka Stream
- Silverstream
- Courtenay Stream
- Greigs Drain
- Upper Eyre River
- Eyre River
- Upper Ohoka Stream
- Coastal Streams

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Appendix B | WRRP flow regimes

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Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

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