Cardrona Flow Regimes

Economic impact assessment of Proposed Plan changes

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Prepared By:

Simon Harris

For any information regarding this report please contact:

Simon Harris

Phone: 0274 356 754

Email: simon@landwaterpeople.co.nz

LWP Ltd
PO Box 70
Lyttelton 8841
New Zealand

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Table of Contents

1 Executive Summary

1. Otago Regional Council (ORC) is undertaking a review of the flow regime for managing the Cardrona River. This is driven partly by the requirements of the National Policy Statement for Freshwater Management which requires the setting of limits on allocation and minimum flows on water bodies.

2. The modelling assesses four scenarios of flow in the upper catchment, and also tests the impact of increasing allocation and use of water. The current reliability is very high, with only limited restrictions based on the availability of water in the river for abstraction. At the 600l/s and 750l/s minimum flows the restrictions are small on average and still provide a high quality supply, although in dry years there are significantly greater restrictions than current for both scenarios. The 900 l/s minimum flow has a greater impact both on average and in dry years. The restrictions on instantaneous takes and total allocation in the upper catchment are unlikely to impact current irrigators based on historic take data, but will impact their ability to increase irrigation.

3. The move to groundwater in the middle reach will have significant costs if the irrigation infrastructure is upgraded at the same time. However there are a number of caveats on this including the feasibility of the shift to groundwater, the increased production with improved irrigation application methods, and the long term shift to subdivision and out of productive land in the middle reach.

4. There is little irrigation in the lower reach, and the extent to which is affected will depend on the flow regime chosen.

5. In the upper and lower reaches there are commercial and communal supplies that would be significantly affected by restrictions on takes. Given the low level of water use and high value associated with these takes the council should consider allowing for them to continue to take at times of restrictions or for inclusion of the communal supplies in Schedule 1B.

2 Background

Otago Regional Council (ORC) is undertaking a review of the flow regime for managing the Cardrona River. This is driven partly by the National Policy Statement for Freshwater Management (NPS-FM) which requires the setting of limits on allocation and minimum flows on water bodies.

A number of scenarios of potential management of water bodies in the Cardrona have been proposed. These divide the catchment in the upper reach above Mt Barker, the middle losing reach, and the lower gaining reach. The scenarios of flow management proposed for each reach are shown below.

Table 1: Scenarios of flow management for Cardrona River

Reach	Scenario	Minimum flow (l/s)	Primary allocation limit (l/s)	Max instantaneous take (l/s)	Other measure	Assessed
Upper Reach	A	None	1291.364	1291.364		Yes
	B	600	600	250		Yes
	C	750	600	350		Yes
	D	900	600	350		Yes
Middle Reach	A	None	593.47			Yes
	E		300-350		Allow for transition	
	F	400l/s (Wanaka race)	593.47			
	G	None	Based on efficient use		Replace surface water takes with unconnected groundwater	Yes
Lower	A	None	63.94			Yes
	H	85% of MALF	63.94			

Of the scenarios proposed, only those for which some data is available are able to be assessed. These are shown in the last column of Table 1, and include all scenarios in the upper reach, the two scenarios in the middle reach, and only the current scenario for the lower reach.

At present use of the available allocation is relatively low at approximately 22% (Henderson and Collins 2019). In the upper reach there is a 600l/s restriction on allocation and a 250l/s and 350l/s restriction on maximum instantaneous take rates. Because current use of the resource is low, it has been assumed for the primary scenarios that these allocation limits in the upper reach will not impact on reliability for users since they will be able to self ration and organise to take at different times. However this assumption may not hold if irrigation increases in the catchment through greater use of water, or if takes from tributaries which dry up and restrict availability were to be moved to other locations. For the purposes of illustrating the impacts of increasing allocation, a further four scenarios were added to the upper reach which illustrate the outcomes if all the irrigation water were used at all times – impacting on both the irrigated area and reliability.

3 Key method and assumptions

3.1 Flow regimes

NIWA (Henderson and Collins 2019) estimated the naturalised flow regime for the upper Cardrona reach and provided this data as a daily time series of flows. PDP (Thomas 2019) estimated the impact of transferring surface water takes in the middle reach to groundwater, but this data was not supplied. Climate data for the upper reach was sourced from NIWA virtual climate station network (VCSN) with a location in the middle of the catchment used (coordinates: -44.775, 169.075). Demand was estimated using a 6 day rolling ratio of rainfall to PET – when rainfall exceeded PET over that period it was assumed that no significant impact on production would arise as a result of an irrigation restriction. Where PET exceeded rainfall an irrigation restriction day was recorded. Thus the restrictions recorded are supply-demand restrictions rather than just supply restrictions, and may vary from those described elsewhere[1].

3.2 Land use and areas irrigated

ORC supplied a consents database for each reach affected, and the upper Cardrona Irrigators Group supplied data on their recorded takes and irrigated area. For the middle and lower reaches the consented takes are used, and for the upper reach the irrigators records are used. For consent data the area irrigated is based upon the average take/irrigated area ratio from the upper Cardrona. All land use is assumed to be sheep and beef, and although no dairy is recorded in the catchment there is some viticulture in the area which does not appear to use surface water. Where irrigation supports viticulture, and this is affected by the irrigation restrictions, the results here may underestimate the total impact. The takes and assumed areas are shown in Table 2.

[1] The impact of not including a measure of demand was tested. It had a small impact (<3%) on average and a slightly larger impact (7%) on worst year impacts for Scenario D, and less impact for the other scenarios.

Table 2: Estimate of take rates and irrigated area by scenario, Cardrona (ha)

Catchment	Scenario	Take rate	Allocation	Irrigated area (sheep and beef)
Upper	A	453.16	453.16	883
Upper	B	250	453.16	883
Upper	C	350	453.16	883
Upper	D	350	453.16	883
Upper	A full take	736	736	1,434
Upper	B full take	600	600	1,169
Upper	C full take	600	600	1,169
Upper	D full take	600	600	1,169
Middle	A	333	333	648
Middle	G	333	333	648
Lower	A	15	15	30

3.3 Other water users

There are a number of consents across the three reaches which are associated with non-irrigation water uses. The impacts on these operations was estimated through interviews, email exchange, document review, and analysis using industry average relationships between employment and revenue and GDP.

3.4 Reliability modelling

The use of a percentage description of reliability at the point of take is a relatively crude indication of reliability and does not automatically indicate the degree of impact on a farmer's ability to apply water and maintain pasture or crop production. Lincoln Environmental[2] identified that *"In its broadest sense, reliability of supply of irrigation water describes the restrictions and water availability an enterprise can expect and the subsequent effect of these restrictions on farm profit. It has aspects of timeliness, steadiness, variability, predictability and is related to user expectations."* There are four aspects needed to accurately describe restrictions.

1. **Severity** or the amount of restriction.

2. **Frequency** or how many times a year that restrictions can be expected and how many years in which they will occur.

3. **Duration** or how long the restrictions last for.

4. **Timing** or when in the production season that the restrictions occur.

The model estimates how much water is available for each flow series and minimum flow point, and if the minimum flow point is breached the appropriate level of restriction is recorded.

The collated data has been used to assess the nature of the irrigation restrictions according to the Lincoln Environmental descriptors in the following way:

[2] Lincoln Environmental: Reliability of Supply for Irrigation in Canterbury. Report No 4465/1, Prepared for Environment Canterbury (June 2001)

- **Severity** is distinguished in this analysis as full or partial restrictions under each of the DNRP flows. Severity is indicated by the number of days in a year in which each of these types of restrictions occur during average, 1 in 4 year, 1 in 10 event and worst year events.
- **Frequency** is shown by the number and frequency of years in which restrictions occur at different severity. This is shown in the second table of results.
- **Duration** is shown by the highest number of consecutive days of restriction at any given severity. Consecutive days of full and 50% restrictions are shown in the first table.
- **Timing** is shown by whether the restrictions occur in the first half of the year or the second half of the year. This is given in the third table of results.

3.5 Financial modelling

The financial analysis is based on interviews with and information provided by the upper Cardrona irrigators group.

Irrigation from the Cardrona river is used by farmers for sheep, beef and deer operations, but for a range of purposes within those operations. Identified uses include feed for weaning lambs onto, flushing and for summer and winter feed crops. Feed crops include lucerne and pasture silage and hay, barley for silage and grain, turnips, swedes, rape, and fodder beet. Reported yields are shown in Table 3.

Table 3: Farmer reported yields for feed crops in the Cardrona valley

Crop	Yield (t/ha)
Turnips	7
Turnips and grass	5 – 6
Swedes	18
Rape	5
Fodder beet	20 – 25
Barley	9 – 10.8
Barley silage (followed by rape)	8
Lucerne	7.8 (plus 8 weeks lamb grazing)
Meadow hay	7.6 (plus grazing)

3.6 Estimating production on irrigated land

Pasture grown on the irrigated area was not able to be estimated directly by the farmers. The analysis therefore relies on work undertaken by Graeme Ogle Consulting for Environment Canterbury on sheep and beef properties in the upper Waitaki - Mackenzie basin, in which he developed three property models – humid, subhumid and dry. The subhumid model represents a property of 2800 ha with 500 – 800mm of rainfall at an altitude of 500 – 700m amsl. For size it is at the upper end of the Cardrona properties, and the Ogle upper Waitaki model has substantially more stock units than the Cardrona ones carry which is likely to be largely associated with the greater areas of flat land that can be developed in the upper Waitaki. Irrigation for the Ogle upper Waitaki model is 149 ha which is also at the upper end of typical irrigated areas in the Cardrona. The property carries merino ewes and cattle, indicating that it is likely to be drier than the Cardrona properties which appear to be predominantly crossbred and halfbreds, where merinos are unsuitable due to footrot problems.

The financial returns on the upper Waitaki properties are not likely to be appropriate for the Cardrona, but the potential for production on irrigated land is likely to be similar because of the closeness of the climatic conditions. The Ogle model is based on a properties which participated in a monitoring programme and so are likely to be reasonably accurate records of production.

The Ogle model estimates 14400kgDM/ha and a stocking rate of 20.3 su/ha on irrigated land. While the model production appears to be at the higher end of the range of production for the Cardrona properties for which information is available, there is other grazing that has not been counted in the Cardrona properties, so the differences are not likely to be substantial and within the range of likely production.

Similarly Porter (2018) estimated the irrigated pasture production in the Tarras catchment at 14,400kgDM/ha and it is therefore considered appropriate to adopt this figure for the irrigated pasture production under an unrestricted reliability of irrigation.

3.7 Returns per stock unit

Data has been received from a limited number of properties, with full financial data from only 1 which is not entirely usable because of some complex activities being undertaken within the property. Irrigators in the catchment report that the properties are not typical high country properties, being smaller in scale and different balance of country. They indicate that returns are likely to be somewhere in between a high country and hill country property, represented by the Class 1 (high country) and Class 2 (hill country) models from Beef and Lamb NZ Farm Monitoring data.

Using data on stocking rates from four properties, the average estimated stocking rate for Cardrona irrigators is 2.77 stock units per ha, which is in between the five year average stocking rate for Class 1 of 1.3su/ha and for Class 2 of 3.9.

Estimates of operating profit were generated from the five year average of data for Class 1 and Class 2 farms, with the expenditure broken down into variable, fixed and depreciation. The figures and breakdown are shown in Table 4.

This data was used to calculate an operating profit and an operating gross margin. The gross margin estimates the impact of changes by decreasing revenue and variable expenses but fixed expenses remain the same.

Table 4: Operating profit estimates for Cardrona Irrigators ($/annum/su).

	Expense type	Beef and Lamb NZ Class 1 High Country	Beef and Lamb NZ Class 2 Hill Country	Cardrona (weighted average)
Stocking rate (su/ha)		1.3	3.9	2.77
Revenue		**$ Per stock unit**		
Total Gross Revenue (per stock unit)		**94.17**	**101.598**	**$98.37**
Expenditure (per stock unit)				
Wages	Variable		$7.64	
Animal Health	Variable	$4.44	$5.23	$4.89
Weed & Pest Control	Fixed	$3.31	$3.90	$3.64
Shearing Expenses	Variable	$6.82	$5.14	$5.87
Fertiliser	Variable	$10.07	$9.66	$9.84
Lime	Variable	$0.81	$0.80	$0.80
Seeds	Variable	$2.11	$2.27	$2.20
Vehicle Expenses	Fixed	$2.58	$2.77	$2.69
Fuel	Fixed	$2.10	$2.28	$2.20
Electricity	Fixed	$0.83	$0.68	$0.74
Feed & Grazing	Variable	$5.11	$6.92	$6.14
Irrigation Charges	Fixed	$0.92	$0.81	$0.86
Cultivation & Sowing	Fixed	$1.96	$1.43	$1.66
Cash Crop Expenses	Fixed	$0.06	$0.04	$0.05
Repairs & Maintenance	Fixed	$5.24	$7.44	$6.48
Cartage	Variable	$1.00	$1.27	$1.15
Administration Expenses	Fixed	$2.41	$2.87	$2.67
Insurance	Fixed	$1.41	$1.66	$1.55
ACC Levies	Fixed	$0.49	$0.60	$0.55
Rates	Fixed	$1.71	$2.07	$1.91
Total Cash Expenditure (per stock unit)		**$53.39**	**$65.48**	**$60.23**
Depreciation	Depreciation	$5.98	$5.84	$5.90
Total operating expenditure (per stock unit)		**$59.37**	**$71.32**	**$66.13**
		Per stock unit		
Operating profit (per stock unit)		**$34.79**	**$30.28**	$32.24
				$0.00
Total revenue (per stock unit)		$94.17	$101.60	$98.37
Variable expenses (per stock unit)		$40.39	$49.35	$45.46
Fixed Expenses (per stock unit)		$13.00	$16.13	$14.77
Depreciation (per stock unit)		$5.98	$5.84	$5.90
Operating profit (per stock unit)		**$34.79**	**$30.28**	**$32.24**
Operating profit impact from reduced stock (per stock unit)		**$53.78**	**$52.25**	**$52.91**

3.8 Impacts of average reliability changes

Three approaches to assessing the value of production off the irrigated land were investigated in a preliminary format.

- Impact on whole property stocking rate from reduced capacity for winter feed retention.
- Direct reduction in production and stock carried on the irrigated land.
- Replacement of feed lost

3.8.1 Reduction in winter carrying capacity.

The analysis assumed 120 days of feed required per stock unit, at 1.1kgDM/day until September, then 1.3kgDM/day to mid September to meet feed requirements. Grass silage and other winter feeds are assumed to be 10MJME/kgDM. This amounts to a total of 150kgDM per stock unit at 90% utilisation. The irrigators in the catchment estimate that 30% of the irrigated land is used for winter feed – either as a crop or preserved feed (silage, baleage, hay, or feed grain).

3.8.2 Replacement of feed lost

An estimated cost for replacing the feed lost is 45c/kgDM, with possibly some additional costs for transport given distance from potential sources. Given the returns per su are only $52.91, replacing the 150 kgDM required for winter feed would exceed the returns, and it is therefore likely to be substantially less expensive to reduce carrying capacity than to purchase in additional feed.

3.8.3 Reduction in production and stocking rate on the irrigated land -

Assuming a stocking rate of 18 su/ha on the irrigated land (Porter 2018), similar to the 20.3su/ha from Ogle but taking into account the heavier stock units), there is a requirement for 640kgDM grown per su at 14,400 kgDM/ha at 80% utilisation.

3.8.4 Method adopted for estimating returns impact of reliability restriction

It is probably most realistic to assume a mixture between reducing stock carried from winter feed loss, and reduced production on the irrigated land. A simple average of these two is $0.175/kgDM lost production.

3.9 Estimating reduced reliability

The assessment method uses a modelling approach that relies on estimating pasture growth losses in restriction events. Data is supplied by ORC on the daily availability of irrigation water for the period of record, and daily rainfall and PET (a measure of daily Potential Evapotranspiration or plant water use) over the same period were sourced from NIWA as described above. The irrigation season is assumed to run from 15 October to 30 April.

The model estimates whether a restriction is likely to have an impact using an indicator of likely demand at that time. The demand indicator is relatively simple and is based on whether the PET exceeds rainfall over the previous number of days. Because the irrigation occurs mainly on light river flats and terraces, a period of 6 days is used. If demand was likely to have occurred, the model records a restriction event and the magnitude of that event based on the availability of water, categorised into <10% available (full restriction), 10 – 50% available, 50 - 90% available, and > 90% available (no restriction).

Where a water supply shortage exists, this is assumed to translate directly into lost production for that period, using a pasture growth curve from reported data for the hearings on the Tarras plan hearings(Porter 2018). An alternative approach to modelling the reductions using ApSim pasture growth module was attempted, but this consistently overestimated soil temperatures and pasture production, so was not utilised further. The conversion into reduced production is likely to overestimate the actual losses because losses in production are not linearly related to days of moisture deficit but have a more complex relationship to soil moisture deficit. However it allows for some delay in post restriction recovery in soil moisture and plant growth, and also allows for that fact that extensive consultation with farmers on the impacts of poor reliability suggest that there are substantial difficulties in addition to the direct loss in pasture production that are associated with negative events in farming such as irrigation restrictions. These may include managing feed curves, sourcing replacement feed, feeding out costs and transitioning difficulties, pasture re-establishment, animal health, stress and cashflow difficulties. It is considered therefore that the overestimate of losses is to an extent compensated for by the other difficulties that climatic variability can create for farm management that cannot be accounted for in this type of modelling.

There is also some potential for overestimation of the occurrence of restrictions because these calculations assume takes from the main stem. However a number of takes are located on tributaries, which dry up prior to the main stem. Some irrigators report that this causes physical restrictions to occur even where they are not restricted by flows on the mainstem. It is likely therefore that some of the restrictions reported would be experienced regardless of the minimum flow required in the mainstem.

Any days of irrigation capability that are lost for each month of the irrigation season are then converted to production lost. This is calculated on a formula of:

$$Total\ Growth\ lost_{month} = \sum Irrigation\ days\ lost_{month} \times Average\ daily\ growth_{month}$$

The irrigation days lost are taken as the total of the restriction water days times the proportion of restriction.

3.10 Catchment and regional outcomes

The per ha outcomes are multiplied by the area in each land use for the catchment and scenario, and these are summed to represent the aggregate outcomes.

The regional outcomes were estimated using an Input/Output (I/O) table for the region supplied by Insight Economics using the sheep, beef and arable sector from the I/O table. The total regional outcomes were calculated as the sum of the direct, indirect and induced effects.

3.11 Transfer to groundwater

The takes in the middle reach include the Wanaka race, Mt Barker race and the Farrant race. There are collectively consents for 593 l/s in the middle catchment which would irrigate nearly 100ha at a 0.6 l/s/ha rate. PDP estimates that there are 648 ha irrigated in the middle reach (Thomas 2019), and the Cardrona irrigators group includes 392 ha irrigated from the three races. This analysis uses the upper figure of 648 ha, and an allowance of 389 l/s of allocation to irrigate this area.

In order to transfer these areas to groundwater the analysis allows for 10 irrigation wells at an average of ~40 l/s per well. It is possible that the area could be covered by fewer wells with PDP (Thomas 2019) allowing for 6 replacement wells, but because of the spread of the area irrigated and fragmented ownership in the middle part of the upper catchment, a larger number of wells is likely to be required. In practice a number of properties would exit from irrigation rather than install wells and upgrade irrigation equipment. A well cost of $20,000 per 250mm well drilled to 30m is allowed for in the analysis. In addition there will be pump and other infrastructure costs (pipes etc) , and there is likely to be a need for some of the properties to upgrade their irrigation equipment if they are using flood based irrigation methods and the analysis allows for $3500/ha of these costs.

No operating costs have been allowed because in general the upgraded irrigation system will substantially outperform older systems, and there is likely to be net positive outcome for irrigators.

In the lower reach there are a number of households, a salmon farming operation and a lodge supplied from the takes in the lower catchment. While they are part of a consent they will be subject to any minimum flows that apply for that water body. Therefore it is possible that with a minimum flow in the lower catchment, these businesses and households could be restricted, with obvious significant consequences. We have used the cost of replacing the communal consented supplies with permitted activity supplies (<25,000 l/day) as an indication of the costs associated with imposing a minimum flow on these consents. The analysis allows for 15 households and 2 commercial supplies, and well depth of 30m and $7700 per drinking water well.

4 Results

4.1 Upper Reach

4.1.1 Irrigation reliability

The estimates of severity of reliability reductions are shown in Table 5 and Table 7 below. They show that currently there are no restrictions, although in practice there will be years when water is not available to irrigators because of unavailability of water for abstraction, particularly for those taking water from tributaries.

In the 600l/s minimum flow scenario there will on average be only minor restrictions, and these will typically not last long. However the restrictions in a 1 in 10 year event rise to 14 days of partial restriction, and nearly 60 days of full or partial restrictions in the worst year on record (1977/78). The volume restriction in the worst year is 20%, but even in a 1 in 10 year even the restrictions are limited to 6% of total volume abstracted.

In the 750 and 900l/s minimum flow scenarios the restrictions increase, and the average volume restriction increases to 5% in the 750l/s minimum flow scenario and 9% in the 900l/s scenario. The 1 in 10 and worst year restrictions also increase substantially. In both these scenarios the users would experience frequent restrictions and in the 900l/s minimum flow scenario full restrictions would occur in 2 years in 5, and some level of restriction would occur in the majority of years.

Table 5:Severity of restrictions for Cardrona River scenario options. Current irrigated area and 250/350 l/s instantaneous take limit

		Full days lost (100% restriction)	50% restriction	25% restriction	Consecutive days of full restriction	Consecutive days of 50% restriction	Volume restriction
Scenario A No min flow	**Average**	0	0	1	0	0	0%
	1 in 4 year event	0	0	0	0	0	0%
	1 in 10 year event	0	0	13	0	0	1%
	Drought year (1977/78)	0	7	38	0	8	7%
Scenario A 300l/s effective min flow	**Average**	0	0	1	0	0	0%
	1 in 4 year event	0	0	0	0	0	0%
	1 in 10 year event	0	0	13	0	0	1%
	Drought year (1977/78)	0	7	38	0	8	7%
Scenario B 600l/s	**Average**	0	2	3	0	1	1%
	1 in 4 year event	0	0	2	0	0	0%
	1 in 10 year event	0	14	6	1	5	6%
	Drought year (1977/78)	30	17	12	11	18	20%
Scenario C 750l/s	**Average**	4	6	9	2	4	5%
	1 in 4 year event	0	5	43	0	2	7%
	1 in 10 year event	3	31	36	2	9	16%
	Drought year (1977/78)	55	19	13	28	30	34%
Scenario D 900l/s	**Average**	10	9	10	4	10	9%
	1 in 4 year event	8	42	17	3	27	19%
	1 in 10 year event	39	32	15	9	34	31%
	Drought year (1977/78)	75	13	4	30	33	43%

Table 6:Severity of restrictions for Cardrona River scenario options. Full allocation used at all times.

Area = Naturalised flow		Full days lost (100% restriction)	50% restriction	25% restriction	Consecutive days of full restriction	Consecutive days of 50% restriction	Volume restriction
Scenario A Status Quo Max Irrigated area	**Average**	0	1	11	0	1	2%
	1 in 4 year event	0	0	15	0	0	2%
	1 in 10 year event	0	8	27	0	2	6%
	Drought year (1997/78)	0	39	41	0	14	17%
Scenario B 600l/s Max Irrigated area	**Average**	1	7	17	1	3	5%
	1 in 4 year event	0	1	56	0	1	9%
	1 in 10 year event	6	22	56	0	5	15%
	Drought year (1997/78)	37	33	20	17	30	32%
Scenario C 750l/s Max Irrigated area	**Average**	5	13	17	2	9	9%
	1 in 4 year event	0	47	28	0	17	17%
	1 in 10 year event	7	61	24	3	34	26%
	Drought year (1997/78)	58	29	8	28	32	41%
Scenario D 900l/s Max Irrigated area	**Average**	12	16	16	5	13	13%
	1 in 4 year event	35	22	14	21	23	24%
	1 in 10 year event	26	38	18	15	20	37%
	Drought year (1997/78)	80	12	12	32	33	49%

Table 7: Frequency of restrictions for Cardrona River Scenario options

	Frequency of years with full days restriction	Frequency of years with 50% restriction	Frequency of years with 25% restriction
Scenario A Status Quo	0	0	0
Scenario B 600l/s	0	1 in 6	1 in 4
Scenario C 750l/s	1 in 4	3 in 8	3 in 5
Scenario D 900l/s	2 in 5	3 in 5	3 in 4

4.1.2 Pasture growth loss

The loss in pasture growth is shown in Table 8 below. It shows that the average pasture growth loss under the 600l/s scenario would be very minor, and even in the worst year scenario it would amount to only just over 10% of the total production.

In contrast for the 900l/s scenario nearly 10% would be lost on average, and one quarter of pasture growth would be lost every 1 in 10 years.

Table 8:Reduction in pasture production for Cardrona River Scenario options

Scenario		Equivalent Growth Days Lost	Pasture Lost (kgDM/ha)	Pasture lost (% of total pasture growth)
Scenario A Status Quo	**Average**	0	0	0%
	1 in 4 year event	0	0	0%
	1 in 10 year event	0	0	0%
	Drought year (1977/78)	0	0	0%
Scenario B 600l/s	**Average**	2	145	1%
	1 in 4 year event	0	21	0%
	1 in 10 year event	0	642	4%
	Drought year (1977/78)	46	1729	12%
Scenario C 750l/s	**Average**	10	596	4%
	1 in 4 year event	0	615	4%
	1 in 10 year event	0	1910	13%
	Drought year (1977/78)	72	4478	31%
Scenario D 900l/s	**Average**	20	1107	8%
	1 in 4 year event	0	1625	11%
	1 in 10 year event	0	3571	25%
	Drought year (1997/78)	85	6062	42%

4.1.3 Financial outcomes from irrigation

The estimated returns from the irrigated area only are shown in Table 9 below. In this analysis the returns per ha are higher than would be typically expected for irrigated area at the 18su/ha stocking rate. This reflects the additional importance of the irrigated area to the whole farm operation. The results show that in an average year the 600 l/s minimum flow results are indistinguishable from those of the current scenario, and are within the margins of error for the analysis. The Scenario C and Scenario D average results show a small average decrease in operating profit. The reductions in per ha operating profit are larger the rarer the event, with the worst year outcomes under the 900l/s scenario showing only 33% of the profit for the average year currently.

Table 9: Per ha financial outcomes for Cardrona River Upper Reach. Current irrigated area and 250/350 l/s instantaneous take limit

Average year		**Average ($/ha)**	**1 in 4 year event ($/ha)**	**1 in 10 year event ($/ha)**	**Worst year (1997/78)($/ha)**
Scenario A Status Quo	Revenue	$2,000	$2,000	$2,000	$2,000
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,200	$1,200	$1,200	$1,200
Scenario B 600l/s	Revenue	$2,000	$2,000	$1,900	$1,800
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,200	$1,200	$1,100	$900
Scenario C 750l/s	Revenue	$1,900	$1,900	$1,800	$1,400
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,100	$1,100	$900	$600
Scenario D 900l/s	Revenue	$1,900	$1,800	$1,500	$1,200
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,100	$1,000	$700	$400

Table 10: Per ha financial outcomes for Cardrona River Upper Reach. Full take and full irrigated area

Average year		**Average ($/ha)**	**1 in 4 year event ($/ha)**	**1 in 10 year event ($/ha)**	**Worst year (1997/78)($/ha)**
Scenario A Status Quo	Revenue	$2,000	$2,000	$1,900	$1,800
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,200	$1,200	$1,100	$900
Scenario B 600l/s	Revenue	$1,900	$1,900	$1,800	$1,500
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,100	$1,100	$1,000	$700
Scenario C 750l/s	Revenue	$1,900	$1,800	$1,600	$1,200
	Expenses	$800	$800	$800	$800
	Operating Profit	$1,100	$1,000	$800	$500
Scenario D 900l/s	Revenue	$1,800	$1,700	$1,500	$1,000
	Expenses	$700	$700	$700	$700
	Operating Profit	$1,000	$900	$700	$300

The average per ha outcomes were aggregated up to the catchment level for the upper Cardrona, and the flow on regional impacts associated with these were included. These are shown in Table 11 below for the current irrigated area and for the maximum allowable irrigated area under each scenario.

The results show that the impact of the reliability changes across scenarios is relatively muted on average and probably within the margins of error. The greater issue is likely to be the variability that arises, particularly with the higher minimum flows. The increased variability leads to less efficient use of available feed because the manager is unable to predict and therefore optimise use across different times of the year, and is forced to keep greater reserves and manage more conservatively.

The impact of available allocation is greater. It provides for changes in the total irrigated area, but also reduces reliability since more of the water will be used. The second analysis shows that the increased irrigated area arising from greater access to water will have more widespread benefits, even under conditions of lower reliability.

Table 11: Aggregate catchment and regional outcomes for Cardrona river upper reach (average only)

Irrigated area	Scenario	Operating profit ($m/annum)	Regional GDP ($m/annum)	Regional Household Income ($m/annum)	Regional Employment (FTE)
Current or limit of allocation	**Scenario A Status Quo**	$1.04	$0.97	$0.23	12.9
	Scenario A 300 l/s minimum accessible flow	$1.04	$0.97	$0.23	12.9
	Scenario B 600l/s	$1.03	$0.96	$0.22	12.8
	Scenario C 750l/s	$1.00	$0.93	$0.22	12.4
	Scenario D 900l/s	$0.96	$0.90	$0.21	11.9
Maximum enabled by allocation	**Scenario A Status Quo**	$1.67	$1.55	$0.36	20.7
	Scenario B 600l/s	$1.32	$1.23	$0.29	16.4
	Scenario C 750l/s	$1.28	$1.19	$0.28	15.9
	Scenario D 900l/s	$1.23	$1.14	$0.27	15.2

4.1.4 Non irrigation water uses in the upper catchment

In the upper catchment there are water uses associated with:

- Communal water supplies
- Mountain resort activities including snowmaking and other skifield activities. Cardrona Alpine Resort Ltd employs 40 full time staff, 560 staff in winter and 100 in summer (Barnes 2016)[3].
- Cardrona Distillery Ltd employs 30 full time staff and 3 part time, of whom all the part time and 24 of the full time staff are in the district.

These operations employ in total 250 – 300 full time equivalent staff (FTE) directly. Based on industry average relationships between employment and revenue and GDP, they are estimated to generate 300 – 350 FTEs in the region, ~$30 million in direct revenue, and $40 – $50 million in total regional GDP. The Cardrona skifield, because it is one of the major attractions for the area, is likely to support a substantially greater contribution to the local economy than is estimated through average industry relationships. In the winter season many of the accommodation, restaurant, retailing and other support services in the Queenstown and Wanaka areas will be at least partially dependent on the operation of the skifield.

The Cardrona ski area winter activity is unlikely to be affected by flow restrictions, because the flow does not drop below the proposed minimum flow levels between April and September in any year for the period of record. Access to water for the summer period is however a more difficult proposition, because access to water for human use, to support restaurant and accommodation services, and for amenity purposes such as dust suppression, will be required over the periods when the river falls below minimum flows. We are unable to calculate the impact of these restrictions.

The Cardrona Distillery is likely to be affected by minimum flow restrictions for the 1l/s consented water take that is consumptive. This would restrict ability to run the still in times of low flow, although there may be some flexibility in terms of timing. However the commercial

[3] Allowing 0.25 – 0.3 FTEs for winter staff, and 0.5FTEs for summer staff.

activities associated with visitors to the distiller complex would be unable to continue at times of greater than 50% restriction because of lack of access to water for cooking, cleaning and toilets. The cost of this has not been calculated, but would cause significant disruption.

Similarly there are two communal water takes in the upper reach (Pure H2O and Cardrona Water Supply Ltd) that currently would be affected by restrictions. The cost of replacing these has not been calculated.

4.2 Middle Reach

The estimated value of irrigation in the middle reach is shown in Table 9 below. It shows that the operating profit is $0.77 million per annum, and it is associated with 0.7 million in regional GDP including flow on impacts, $0.17 million in gross household income, and 9.5 FTEs of employment at full uptake of irrigated area. It should be noted that currently there are parts of the potentially irrigated area that are not being utilised, although this may change in the future. There is also a trend for lifestyle blocks to replace productive farms in the area, which over time is likely to lead to less use of the irrigation water.

The cost of replacing irrigation wells in the middle reach is estimated at $0.2 million for wells and $2.3 million for the associated irrigation infrastructure. The total cost for irrigating the 648 ha is estimated at $2.5 million, equivalent to an annuity of $190,000 per annum over 25 years.

Table 12: Aggregate catchment and regional outcomes for Cardrona river middle reach (average only)

Scenario	Operating profit ($m/annum)	Regional GDP ($m/annum)	Regional Household Income ($m/annum)	Regional Employment (FTE)
Cardrona Middle Current reliability	$0.77	$0.71	$0.17	9.5

4.3 Lower reach

The lower reach has an irrigation take that is utilised for 30 ha of irrigation, and a 1ha orchard is under consideration. Currently with no minimum flow on the river the estimated value of the irrigation is $0.04 million per annum in operating profit and less than 1 FTE. This could increase with greater irrigation enabled by the available allocation, but is not currently planned by consent holders. There are potential plans for an additional 1ha of orchard irrigated from one consented irrigation take, but these are not firm plans and have not been costed in this analysis.

The salmon farm operates under a permitted activity take, although this can potentially be ordered to cease take if the council chooses to do so once minimum flows are defined in the lower river.

It is unlikely that restrictions on the lower reach would have major implications for irrigators given the small size of the irrigated area, although for the one property irrigating there could be some issues similar to those in the upper catchment, particularly associated with winter feed supplies, and feed during the summer drought period. The nature of any restrictions would need to be determined once data is available on flows, and once the desired minimum flow has been determined.

The cost of replacing the communal supply to households and commercial with individual wells would be $0.13 million, equivalent to an annuity of $10,000 per year over 25 years.

Table 13: Aggregate catchment and regional outcomes for Cardrona river lower reach (average only)

Irrigated area	Scenario	Operating profit ($m/annum)	Regional GDP ($m/annum)	Regional Household Income ($m/annum)	Regional Employment (FTE)
Current (30ha)	**Scenario A Status Quo**	$0.04	$0.03	$0.01	0.4
Maximum enabled by allocation (56.4 ha)	**Scenario A Status Quo**	$0.07	$0.06	$0.01	0.8

5 Summary

The current flow management regime on the upper Cardrona offers a high degree of reliability, with near 100% reliability constrained only by the ability to take water from the river. Even allowing for an effective minimum flow of 300l/s so that there is sufficient water available for abstraction, there are only limited partial restrictions in a few years. There are irrigators on tributaries of the Cardrona for whom their take points dry out before the mainstem, and these users will experience lower reliability than those on the mainstem.

The 600l/s and 750l/s regimes still provide for a highly reliable water source, with on average >95% of the water available at times of demand. The financial impacts of these two scenarios is limited on average, although in dry years they are significantly more impacted than the current regimes. The 900l/s minimum flow results in an average of ~10% in pasture production loss from irrigated land, and in dry years there are significant impacts on availability of water at times of demand. In financial terms the per ha impact of the 900l/s minimum flow is ~8% on average reduction in operating surplus.

The impact of these regimes on aggregate and regional outcomes is determined by changes in minimum flow and available water for use. The current irrigated area in the upper catchment uses only part of the available allocation, and the maximum rate of take is substantially below the available allocation. Therefore the limitation of 600l/s total take in each of scenarios B, C and D will have little impact on current irrigators, and it appears likely that the 250l/s and 350l/s restrictions on instantaneous takes will also be below historic instantaneous take rates. However it will constrain the ability of irrigators to increase their irrigated area, with the potential aggregate operating profit ~25% less under Scenario D than Scenario A. Similarly contribution from the irrigated area to regional GDP would be ~20% less, and employment ~25% less. The potential for increased irrigated area and increased use of irrigation has the potential to increase the instantaneous take rates above the 250/350 l/s limit imposed in Scenarios B, C and D, and this would further reduce the apparent reliability, particularly in dry years.

In general – if a take is consented it is subject to the minimum flow except:

- Non-consumptive ones
- Communal supplies in schedule 1B

- There is a condition on the resource consent

None of the supplies in the Cardrona are listed in Schedule 1B. The use of water for non irrigation purposes, including the skifield, distillery and water supplies is likely to be constrained by the minimum flow being imposed in the upper catchment. The skifield winter operation is unlikely to be affected, but the summer operation could be significantly curtailed if they are unable to take water for their operation. Similarly the distillery would be forced to close for the period of the flow restrictions, and particularly for full restrictions. Given the high level of returns both locally and regionally from these operations compared with the low level of water takes, it would make sense to allow for continuation of takes for the commercial operations during periods of low flows. There is also a need to ensure continuity of supply for domestic water being supplied from communal sources during periods of flow restriction, and the council should consider whether these should be included in Schedule 1B.

The analysis of the middle reach shows that the cost of moving to groundwater is potentially significant, at an equivalent annual cost of $190,000 for the irrigators. However there are a number of caveats that should be considered, including:

- It is unclear whether there is sufficient groundwater available at a reasonable depth to allow for the conversion to bore sources.
- The analysis allows for improved infrastructure and application methods, which typically lead to improved pasture production. In other parts of the country the shift from flood based or inefficient spray systems typically produces sufficient pasture to pay for the cost of the shift, although this may not be the case on a lower value sheep and beef operation.
- The irrigated area in the middle reach is the subject of substantial demand for residential, large residential and lifestyle block development. For a number of irrigators in this area the returns from subdivision will be an order of magnitude or more greater than the returns from continuing to irrigate, and subdivision is therefore likely to be the ultimate fate of this land. Conversion to residential and lifestyle blocks will reduce the demand for irrigation from the middle reach over time.

There is very little irrigation in the lower reach, and the impacts of any future flow management regime are unknown but unlikely to be significant on a local or a regional scale, although they may be important to the irrigator affected. The effect of water on consents used for commercial and communal water supplies is likely to be more significant, and the council should consider whether any of these takes should be included in Schedule 1B.

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7 References

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