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Economic impacts of minimum flows in the Manuherikia Catchment

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Executive summary

This report quantifies the potential effects to economic activity and employment from changes to farm-level activity in response to different minimum permitted flows within the Manuherikia Catchment (the Catchment). These effects have been calculated for both Central Otago and Otago Region.

This economic modelling builds on farm-level financials and land use statistics provided by Otago Regional Council commissioned consultants.

Key findings – status quo baseline

- The modelling in this report highlights that under the current status quo flow regime, the direct GDP contribution from irrigated farming in the Catchment is $17.6 million during an average rainfall year. This estimate excludes horticulture for reasons outlined on the following page.
- This level of direct GDP is equivalent to 20% of livestock and dairy farming GDP across Central Otago and represents about 1.2% of Central Otago's economy.
- These direct GDP effects from farm-level activity can also be considered alongside downstream effects that also occur from farm wages being spent, as well as farmers buying in goods and services for use on the farm.
- Considering downstream and direct effects together suggests that the total GDP effect of irrigated farming in the Catchment could currently be as high as $27.8 million in Central Otago. Across Otago as a whole, this total GDP effect is estimated to be as much as $33.4 million during an average year. The effects are slightly higher across Otago due to broader supply chains and increased processing capacity at a regional level.
- From an employment perspective, it is estimated that there could be as many as 180 direct jobs supported in Central Otago from farming in the Catchment under status quo flows in an average year, with as many as a further 125 jobs supported downstream. Together, these suggest the total employment contribution could be 305 jobs in Central Otago during an average rainfall year.

Table 1

Total Central Otago/Otago GDP from irrigated farming in the Catchment under status quo flows
Total GDP (direct + downstream) in $ millions. Source: Author calculations, AbacusBio, Davis Ogilvie

	Direct GDP	Total GDP (direct and downstream effects)	
	Central Otago	**Central Otago**	**Otago**
Average year	$17.6m	$27.8m	$33.4m
Wet year	$20.1m	$31.4m	$37.6m
Dry year	$12.8m	$20.7m	$25.1m

Table 2

Central Otago/Otago employment supported by irrigated farming in Catchment with status quo
Employment supported by the sector under status quo flows, Source: Author calculations

	Direct employment	Total employment (direct and downstream)	
	Central Otago	**Central Otago**	**Otago**
Average year	180	305	375
Wet year	206	346	424
Dry year	126	222	278

Key findings - the effects of different minimum flow scenarios

- Alongside the status quo minimum flows regime (~820 l/s), this report also considered five other minimum flow scenarios (900 l/s, 1,500 l/s, 2,000 l/s, 2,500 l/s, and 3,000 l/s).
- The impairments to economic activity and employment are greater as minimum flows increase because irrigation water takes will be more constrained under higher flows. Nevertheless, the impairments are relatively small up to 1,500 l/s, but are substantial under a 3,000 l/s scenario.
- During an average rainfall year, the Central Otago's total GDP across both direct and downstream channels could be as much as 19% lower in a 3,000 l/s scenario, compared to the status quo benchmark. This impairment would reduce to 5.2% at a 1,500 l/s minimum flow level.
- The effects of different minimum flow scenarios are even more pronounced during dry years, which are the years when farmers are most reliant on their irrigation systems.
- During a dry year, the impairment to Central Otago's total GDP across both direct and downstream channels from irrigated farming in the Catchment could be as much as a 50% reduction in a 3,000 l/s scenario, compared to the status quo benchmark. Under a 1,500 l/s minimum flow regime, the total reduction in the Catchment's contribution to Central Otago's GDP would be 9.8%.
- There are similar impairments evident in estimates of employment effects, and when GDP and employment effects are considered from an Otago-wide perspective.
- Two key limitations should be factored in when interpreting these results:
    - These estimates only account for the immediate impairment from different minimum flows, but longer-term adaptation by farmers to mitigate the effects have not been addressed. The reason is that Otago Regional Council has not modelled land use changes under different minimum flows. But in reality, it is likely that there will be tipping points, particularly under high minimum flow scenarios, where the impairments to yields for certain farming systems are so great that long-term land use changes are necessary. More work must be done by Otago Regional Council to understand adaptive behaviour.
    - The estimates in this report considered dairy, dairy support, and sheep and beef farming only. Horticulture was not captured because insufficient work was commissioned by Otago Regional Council to understand horticultural returns and land use. This omission could be significant because even though only 4% of land in the Catchment is in horticulture, value add from horticulture will be much higher because crops such as cherries and vineyards offer much better yields than dairying and other farming systems.

Table 3

Total GDP under different minimum flows in the Catchment
Total GDP (direct + downstream) measured in $ millions for each scenario

		Minimum flow scenario					
		Status quo (~820 l/s)	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Central Otago	**Average year**	$27.8m	$27.2m	$26.3m	$25.2m	$23.9m	$22.6m
	Wet year	$31.4m	$31.4m	$31.2m	$31.0m	$30.5m	$29.6m
	Dry year	$20.7m	$19.8m	$18.6m	$16.6m	$13.3m	$10.3m
Otago Region	**Average year**	$33.4m	$32.7m	$31.8m	$30.6m	$29.1m	$27.6m
	Wet year	$37.6m	$37.5m	$37.4m	$37.2m	$36.6m	$35.6m
	Dry year	$25.1m	$24.1m	$22.8m	$20.5m	$16.8m	$13.5m

Table 4

Total employment from irrigated farms under different flows *Total employment (direct + downstream) under each scenario*							
		Minimum flow scenario					
		Status quo (~820 l/s)	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Central Otago	**Average year**	305	298	289	277	261	247
	Wet year	346	346	345	342	336	327
	Dry year	222	212	199	176	139	106
Otago Region	**Average year**	375	368	357	344	327	312
	Wet year	424	424	422	420	413	403
	Dry year	278	267	252	226	185	147

Background to the report

About the report

The aim of this report is to quantify the potential effects to economic activity and employment in Central Otago and Otago Region from changes to minimum flows within the Manuherikia Catchment (the Catchment). Any changes to minimum flow levels will alter farm-level practice for those reliant on irrigation, as well as have downstream influences on supply chains and household spending patterns.

This report has been commissioned by Central Otago District Council to give background context to potential water management options for the Catchment that will be consulted on by Otago Regional Council. Six different minimum flow scenarios have been considered, across wet, average, and dry years. The farming systems included were dairy, dairy support, and sheep and beef farming.

Limitations of the analysis

The economic analysis undertaken in this report builds on farm-level financial models, which were developed by AbacusBio for Otago Regional Council[1]. These farm-level financial models were analysed along with summary data on current land use across the Catchment using data provided by Davis Ogilvie (hydrologists) based on their analysis of Otago Regional Council databases.

The farm-level financials and land use statistics were key inputs into economic modelling of the likely changes in economic activity and employment from imposing different minimum flow levels on the Catchment. Any errors or omissions in this base data will affect the results of the economic analysis. An example of such an omission is that Otago Regional Council didn't assess potential land use changes in response to different minimum flows, consequently, this report can only consider the immediate costs during a single year under existing land use and not offsets due to transitions between farming systems.

The economic analysis has focussed on dairy, dairy support, and sheep and beef farming. Horticultural activity has been excluded because of the unavailability of sufficiently detailed land use data and farm-level financials for different horticultural types under different minimum flow scenarios. Horticultural land accounts for a small share of the affected land area (approximately 4% of affected irrigated land), but because of its high value per hectare (eg. cherries commonly offer 10-12 times the gross margin of dairy and some ultra-efficient cherry orchards even offer higher relative returns), the sector's share of value add will be much higher. Otago Regional Council should undertake more detailed work to comprehensively understand the effects on horticultural land use and financial returns.

The economic impacts considered in this report are not a full cost-benefit or socio-economic analysis. As such, there is no consideration of the environmental effects which arise from any changes to farming practice, or any cultural costs or benefits. Furthermore, because of the nature of base data available, this report has only analysed the income effects from changes to farm-level profitability. It would be better to also consider the wealth effects that occur because of the negative effects of water scarcity on land values. Wealth effects can affect future investment decisions and farmers' capacity to carry debt.

[1] The farm-level financial models relied on in this report from AbacusBio were also utilised in catchment-wide scaling of farm returns by Lewis Tucker. These models were peer reviewed by Compass Agribusiness on behalf of Central Otago District Council. Compass Agribusiness's peer review report (dated 25 March 2021) was broadly comfortable with the ballparks of the models' high level outcomes, but suggested some specific methodological improvements for future updates.

Input data and methodological approach

This section outlines the land use, minimum flow scenarios, and farm financial data used as inputs into the economic modelling. It also describes conceptually how the economic modelling took these inputs to estimate potential direct and downstream effects on economic activity and employment.

Land use in the Manuherikia

Land use data relied on in this report has been modelled by Davis Ogilvie (hydrologists)[2] based on their analysis of irrigation and land use information provided to them by Otago Regional Council.

The data shows the full Manuherikia catchment has 27,210 hectares of irrigated land, of which 8,926 hectares (mainly in the Ida Valley) are outside of areas that will be affected by higher minimum flows.

The analysis in this report focusses on the remaining 18,284 hectares in the Catchment that have been identified by Davis Ogilvie as being significantly affected by higher minimum flows. The reliability zone of this irrigated land, and the type of farming system it is currently used for is identified in the following table. Note that the reliability zone for Tributaries captures Dunstan, Lauder, Thomsons and Chatto.

Table 5

Irrigated land in the Catchment that will be significantly affected by higher minimum flows
Data from Davis Ogilvie based on analysis of Otago Regional Council information, as at 17/02/21

	Land use				
Reliability zone	**Dairy**	**Dairy support**	**Sheep/beef**	**Hort***	**Total**
Upper Manuherikia	2062	1376	3340	-	**6,778**
Tributaries	452	951	5672	-	**7,075**
Lower Manuherikia	-	886	2922	624	**4,431**
Total	**2,514**	**3,213**	**11,934**	**624**	**18,284**

Within the land use data above, Davis Ogilvie has cautioned that the quality of horticultural land use data from the Otago Regional Council is low across different types of horticultural applications. Because of these quality concerns, and a lack of sufficiently detailed horticultural financials from AbacusBio, we have been forced to exclude horticulture from the economic analysis. As noted in the previous section, even though this means that only approximately 4% of land is excluded, the contribution to economic value add from horticulture will be much higher because crops such as cherries and vineyards offer much better yields per hectare than dairying and other farming systems.

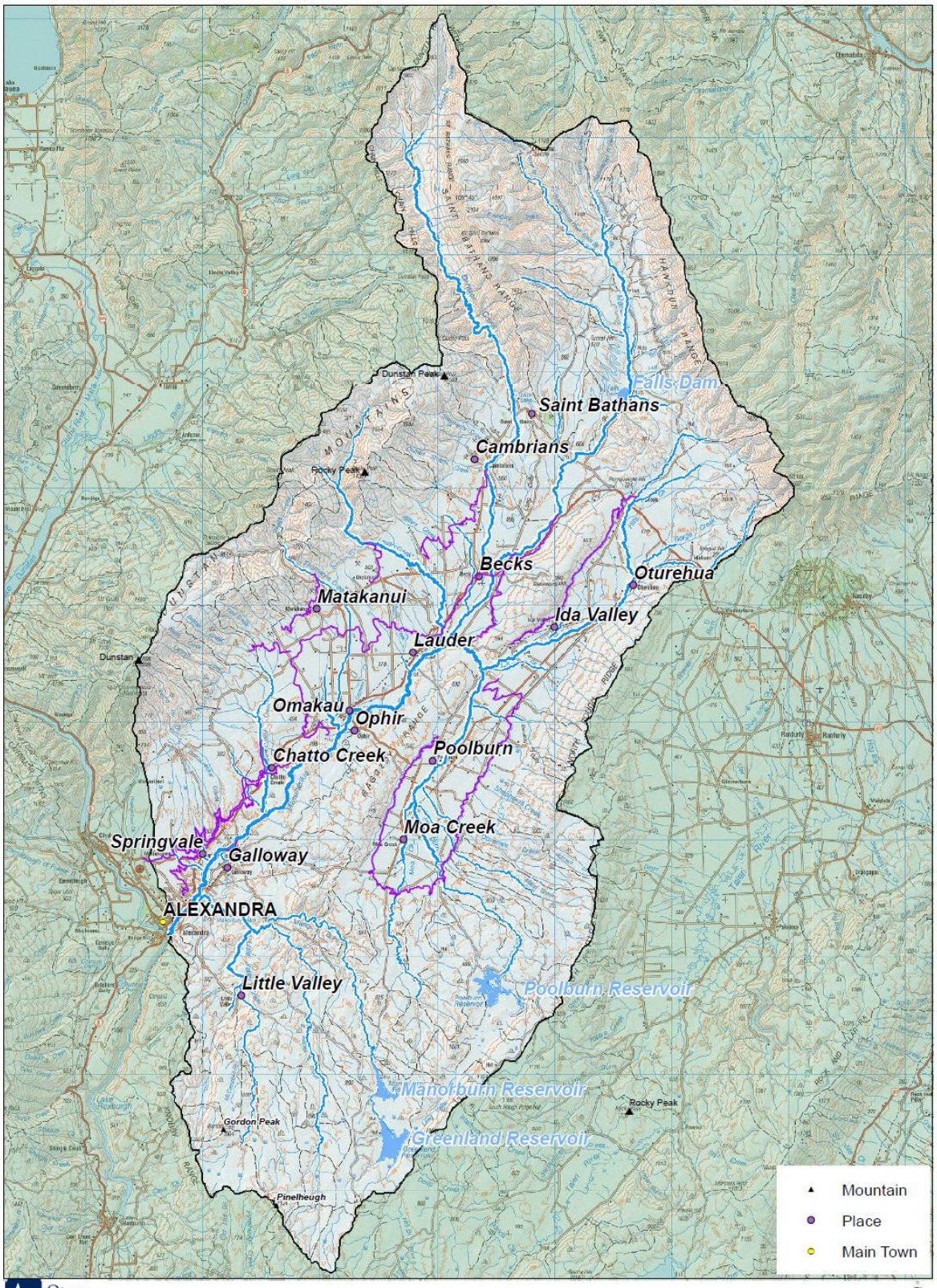
The following table shows total land use across the Catchment excluding horticulture. This total hectarage was the total baseline used for analysis in this report.

Table 6

Irrigated land (excluding horticulture) in the Catchment affected by higher minimum flows
Includes: dairy, dairy support, sheep/beef. Davis Ogilvie modelling from Otago Regional Council data

Reliability zone	**Total (hectares)**
Upper Manuherikia	6,778
Tributaries	7,075
Lower Manuherikia	3,808
Total	**17,661**

[2] Land use data is based on analysis provided from Davis Ogilvie as at 17 February 2021.



Otago Regional Council

Manuherikia Catchment

0 1 2 4 6 8
Kilometres

Date generated: 11/08/2016

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Minimum flow scenarios

There were six potential minimum flow scenarios considered in the farm-level financial models that were provided to us by AbacusBio.

Table 7

Minimum flow scenarios for the Manuherikia considered in the analysis *Flow scenarios in l/s that align with AbacusBio modelling and ORC consultation documents*	
Flow scenarios:	**l/s (at Campground)**
Status quo - no minimum flow at Campground and 820 s/s at Ophir	<820
900 l/s – current voluntary operational goal	900
1,500 l/s – potential minimum flow scenario	1,500
2,000 l/s – potential minimum flow scenario	2,000
2,500 l/s – potential minimum flow scenario	2,500
3,000 l/s – potential minimum flow scenario	3,000

Within each scenario, subsequent financial modelling was also undertaken across dry, wet and average rainfall seasons. These rainfall scenarios were based off annual irrigation demand during the driest and wettest sustained three-year periods in hydrological data stretching from 1973 to 2020.

Farm-level financials

The AbacusBio data captures the effects of each minimum flow scenario in dry, wet, and average rainfall years on the farm-level financials of each farming type. The farming types that were given detailed consideration were dairy, dairy support, and sheep and beef. Only irrigated farming systems were assessed as these are the ones affected by changing minimum flows.

The AbacusBio analysis contains very detailed line-by-line information on various aspects of revenue and expenditure, but for the purpose of economic modelling across the Catchment only total sales, and the combination of EBITDA (earnings before interest, taxation, depreciation and amortisation) with wages and salaries[3] were needed. Tables of AbacusBio data used in this report can be found in the appendix.

The AbacusBio model outputs have been reviewed by Compass Agribusiness on behalf of Central Otago District Council – this review was broadly comfortable with the models' high level outputs, but suggested some methodological improvements that could be done.

AbacusBio has assumed that farmers' margins are squeezed with less water because their response is to buy in more dry feed for livestock. No material revenue impairments or land use changes have been considered, because AbacusBio's analysis assumes additional dry feed purchases reduce the need for material reductions to stock levels, even in extreme high minimum flow scenarios.

Direct economic and employment effects in Central Otago

The farm-level financials outlined above was used as a key input to calculate the direct economic and employment effects of farming in Central Otago under different minimum flow level scenarios. Within the farm-level financial data, EBITDA and wages and salaries were used as a starting point. The reason is that economic value add, or GDP as it is also known, measures the returns that accrue to labour and

[3] The reasons why these specific financial indicators were necessary will be explained in the next sections of this report which outline the methodology for accessing direct and broader economic effects.

capital (financial, physical, intangible), which is what EBITDA and wages and salaries essentially capture in accounting terms at a farm-level.[4]

To scale up this farm-level economic value add, EBITDA and wages and salaries for each farming system were multiplied by the hectares of land used and summed together to arrive at an estimate of total direct GDP from farming in the Catchment. This process was repeated across each minimum flow scenario.

The direct levels of employment supported by these GDP scenarios were then estimated using industry level direct GDP to employment multipliers supplied by Infometrics. These multipliers were sourced from Infometrics to ensure consistency with other economic and employment data used in publicly available resources which Central Otago District Council has previously commissioned[5].

Downstream effects in Central Otago

Alongside the direct economic and employment effects to Central Otago from irrigated farming in the Catchment, there are also downstream effects for other industries. These effects are because:

a) There is additional value added from the procurement of other goods and services as inputs into farming systems (known as indirect effects). For example, accountancy and legal services, maintenance of machinery, paying rural contractors for fencing or harvesting support, etc.
b) The recirculation of wages earned by workers in the farming sector back into other industries within the district (known as induced or earnings effects). For example, a farm worker spending some of their wages on retail or hospitality within the district.

The additional downstream effects from the indirect and earnings channels were captured by applying multipliers sourced from Infometrics to the direct economic and employment effects calculated earlier. These multipliers take into consideration inter-industry relationships in the local economy.

The multiplier analysis should be taken as a theoretical maximum of additional downstream economic activity supported by agriculture, because in the absence of the sector, some of the downstream resources could be applied to other uses. For example, a rural contractor may pivot to home landscaping support. However, the redeployment of these downstream resources would likely occur in a less productive manner, otherwise they would have already been focussed on servicing demand for other sectors or elsewhere in New Zealand.

[4] Some studies use a slightly different concept called gross value add. Gross value add differs from GDP (economic value add) in that it adjusts GDP for taxation to government and subsidies to the local area. This study has used GDP to be consistent with other regional economic activity measures released publicly by Infometrics and Statistics New Zealand, as these sources both use GDP.
[5] Infometrics Central Otago Regional Economic Profile is available here.

Economic and employment effects more broadly across Otago

On top of the direct and downstream effects within Central Otago, there are also other effects that accrue to the rest of Otago Region. Some of these additional effects occur because multiplier effects are greater across a broader geographical area. In short, there are a wider range of goods and services across Otago supplying farming systems in the Catchment than those that are available locally in Central Otago.

Furthermore, there is also another avenue of value add that must be considered – the processing of agricultural products from farms after they leave the farmgate. This report has assumed that 50% of meat from the Catchment is processed within Otago Region, while all milk is processed outside of the region[6].

[6] The milk processing assumption is consistent with a 2016 report by Butcher Partners (Manuherikia Irrigation Scheme: Regional and District Economic Impacts). The Butcher report further assumed 70% of meat from the Catchment is processed in Otago, but discussions with industry sources during the development of the current report have suggested that a 50% share would be more appropriate to use.

Economic activity and employment under status quo

This section provides results from analysing the direct and downstream effects on economic activity and employment of irrigated farming in the Catchment under the current status quo flow regime. The analysis is designed to give a baseline understanding under status quo flows for both Central Otago and more broadly across Otago Region. In the next section of this report, we will consider how different minimum permitted flow scenarios will affect these results.

Economic activity under the status quo in Central Otago

The direct GDP (economic activity) effects under the status quo flow scenario are summarised below in the following table. These calculations have been performed using the land use, farm financial data and methodological approach described in the previous section.

Table 8

Direct GDP in Central Otago from irrigated farming in the Catchment under status quo flows
Direct GDP is measured in $ millions. Source: Author calculations, AbacusBio, Davis Ogilvie

	Average year	Wet year	Dry year
Average EBITDA + wages & salaries per hectare	$999	$1,136	$724
Multiply by: total irrigated farmland	17,661 hectares	17,661 hectares	17,661 hectares
Direct GDP	**$17.6m**	**$20.1m**	**$12.8m**

The calculations show a direct GDP contribution during an average rainfall year of $17.6 million from irrigated farming in the Catchment under the status quo flow regime. This level of direct GDP is equivalent to 20% of livestock and dairy farming GDP across Central Otago[7] and represents about 1.2% of Central Otago's economy.

During a dry rainfall year, this direct GDP contribution would fall to $12.8 million, while during a wet year, when pasture growth was better, it would rise to $20.1 million.

The $17.6 million direct GDP contribution of irrigated farming in the Catchment during an average rainfall year estimated in this report compares to a $28 million direct GDP in a similar scenario within a 2016 report by Butcher Partners that analysed the effects of additional irrigated farmland if a proposed dam was constructed[8].

These direct GDP effects can also be sat alongside the downstream effects of this activity on supply chains and household spending to get a total GDP effect across direct, indirect and earnings channels.

Table 9

Total GDP in Central Otago from irrigated farming in the Catchment under status quo flows
Total GDP (direct + downstream) in $ millions. Source: Author calculations, AbacusBio, Davis Ogilvie

	Average year	Wet year	Dry year
Direct GDP	**$17.6m**	**$20.1m**	**$12.8m**
Indirect and earnings effects (downstream)	$10.1m	$11.3m	$7.9m
Total GDP (direct and downstream channels)	**$27.8m**	**$31.4m**	**$20.7m**

[7] As measured by Infometrics Central Otago Economic Profile (2020).
[8] The report assessed three potential storage options for a dam proposal on the Manuherikia – the irrigated land supported by the middle of the three options (20,000 hectares) in the Butcher report most closely corresponds to the existing land use analysed in this report (17,661 hectares).

The data shows that the total GDP in Central Otago, supported by both direct and downstream channels from irrigated farming in the Catchment under the status quo flow regime, in an average year is $27.8 million.

This estimate should be taken as a theoretical maximum of additional downstream economic activity supported by farming because in the absence of the sector, some of the downstream resources could be applied to other uses. For example, a rural contractor may pivot to home landscaping support. However, the redeployment of these resources would likely occur in a less productive manner than currently occurs, otherwise they would have already been focussed on servicing demand for other sectors or elsewhere in New Zealand.

Employment under the status quo in Central Otago

The following table highlights the direct and downstream employment supported by irrigated farming activity in the Catchment under the status quo flow regime.

Table 10

Employment in Central Otago supported by irrigated farming in the Catchment under status quo
Employment (direct + downstream) supported by the sector. Source: Author calculations

	Average year	Wet year	Dry year
Direct employment	180	206	126
Indirect and earnings effects (downstream)	125	140	96
Total employment (direct + downstream)	**305**	**346**	**222**

The calculations show a direct employment contribution during an average rainfall year of 180 jobs, while there are as many as a further 125 jobs supported downstream from indirect and earnings effects. Together, these suggest the total employment contribution could be as high as 305 jobs during an average rainfall year.

The direct employment contribution of irrigated farming in the Catchment during an average rainfall year (180 jobs) is equivalent to 21% of employment in livestock and dairy farming across all of Central Otago (in Infometrics Central Otago Economic Profile) and represents 1.3% of all jobs in Central Otago.

Potential employment effects of dry and wet years have also been modelled. These two scenarios are driven by different levels of underlying economic activity compared to average rainfall years. These results should be interpreted with caution as they are likely to overstate employment volatility in response to a single dry or wet year. In the real world, employers will only minorly adjust their staffing levels to one-off events, even if their underlying profits have changed more rapidly. Put simply, an employer will hire most of their workforce base on their long-term activity expectations, rather than a single year-to-year fluctuation.

Wider effects on the region under the status quo

On top of the direct and downstream economic activity and employment effects from irrigated farming in the Catchment that stay within Central Otago, there are also other additional effects that accrue to the rest of Otago Region. As outlined in the methodology section, some of these additional effects occur because multiplier effects are greater when you look across a broader geographical area. Other effects also accrue to the region because of processing of products from the Catchment's farms in other parts of Otago.

The following table summarises the direct and downstream economic effects across Otago compared to those in Central Otago under status quo flows.

Table 11

Total Central Otago/Otago GDP from irrigated farming in the Catchment under status quo flows
Total GDP (direct + downstream) in $ millions. Source: Author calculations, AbacusBio, Davis Ogilvie

	Direct GDP	Total GDP (direct and downstream effects)	
	Central Otago	**Central Otago**	**Otago**
Average year	$17.6m	$27.8m	$33.4m
Wet year	$20.1m	$31.4m	$37.6m
Dry year	$12.8m	$20.7m	$25.1m

The calculations show that total GDP in Otago across direct and downstream channels from irrigated farming in the Catchment could be as high as $33.4 million during an average rainfall year. This result compares to a total GDP effect of $27.8 million within Central Otago. Downstream effects should be treated as a theoretical maximum for reasons outlined earlier.

Interpreting these figures in a different way suggests that 83% of the total GDP effects accrue to Central Otago, while 17% of the effects accrue to other parts of Otago.

These effects can also be considered from an employment perspective. The following table summarises the direct and downstream employment effects across Otago compared to those in Central Otago.

Table 12

Central Otago/Otago employment supported by irrigated farming in Catchment with status quo
Employment supported by the sector under status quo flows, Source: Author calculations

	Direct employment	Total employment (direct and downstream)	
	Central Otago	**Central Otago**	**Otago**
Average year	180	305	375
Wet year	206	346	424
Dry year	126	222	278

The calculations suggest that total employment in Otago that is supported by direct and downstream channels could be as high as 375 jobs during an average rainfall year. This result compares to a total employment effect of 305 jobs within Central Otago.

Effects of different minimum flow restrictions on economic activity and employment

This section considers how different minimum permitted flows could affect economic and employment activity generated by irrigated farming in the Catchment, compared to the status quo flow scenario.

Analysis does not factor in changes to long-term land use

It is important to highlight that Otago Regional Council has not explicitly modelled land use changes under different minimum flows. This means that the analysis of economic activity and employment in this report is also forced to make such an assumption. As such, this report's results are limited to showing the immediate impairment to economic activity and employment from different minimum flows, but longer-term adaptation by farmers to mitigate the effects cannot be directly addressed.

Otago Regional Council's approach has been to assume that farmers will simply use more dry feed if they have less water, rather than reconsider the long-term most efficient use of their land. In reality, it is likely that there will be tipping points, particularly under high minimum flow scenarios, where the impairments to yields for certain farming systems are so great that long-term land use changes are necessary. For example, there may be a shift from dairying at a highly affected farm to a less water intensive use such as dairy support, or sheep and beef.

Not taking into account land use changes reduces the credibility of interpretations from the farm financial models commissioned by Otago Regional Council. The effect can be to overstate some of the long-term downside risks to economic activity because changes of land use would be an adaptation by farmers to minimise the costs of a new water regime and find an economically higher yielding model. The ramifications for long-term employment are less clear because at a farm level, switching to sheep and beef uses less direct employees than dairying, but this outcome would be offset by multiplier effects on downstream employment of better economic activity than if such adaptation had not occurred.

Economic effects in Central Otago of changing minimum flows

The direct economic effects to Central Otago of changing minimum permitted flows are summarised in the following table.

Table 13

Direct GDP in Central Otago from irrigated farms under different minimum flows
Direct GDP (measured in $ millions) under each scenario

	Minimum flow scenario					
	Status quo	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Average year	$17.6m	$17.2m	$16.7m	$16.0m	$15.1m	$14.3m
Wet year	$20.1m	$20.1m	$20.0m	$19.8m	$19.5m	$18.9m
Dry year	$12.8m	$12.2m	$11.4m	$10.1m	$8.0m	$6.0m

Calculations from the above table shows that during an average year direct GDP in Central Otago from irrigated farms under their current land use would be 19% lower under a 3,000 l/s minimum flow level scenario, compared to its status quo level. This impairment would reduce to 5.3% at a 1,500 l/s minimum flow level.

Understandably there would be no discernible effect in wet years when there would be plenty of rainfall for pasture growth without the need for extensive irrigation.

The impairments to direct GDP are most apparent during dry years, which are the years when farmers are most reliant on their irrigation systems. During these years, direct GDP in Central Otago from irrigated farming in the Catchment under a 3,000 l/s minimum flow scenario would be 53% below its status quo benchmark level, while even under a 1,500 l/s minimum flow regime direct GDP would still be 10% down.

The downstream effects on supply chains and household spending of higher minimum flow scenarios are also significant. These are summarised in the table below.

Table 14

Total GDP in Central Otago under different minimum flows in the Catchment
Total GDP (direct + downstream) measured in $ millions for each scenario

	Minimum flow scenario					
	Status quo	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Average year	$27.8m	$27.2m	$26.3m	$25.2m	$23.9m	$22.6m
Wet year	$31.4m	$31.4m	$31.2m	$31.0m	$30.5m	$29.6m
Dry year	$20.7m	$19.8m	$18.6m	$16.6m	$13.3m	$10.3m

Calculations from the data shows that during a dry year the impairment to Central Otago's total GDP across both direct and downstream channels from irrigated farming in the Catchment could be as much as a 50% reduction in a 3,000 l/s scenario, compared to the status quo benchmark. Under a 1,500 l/s minimum flow regime, the total GDP decline would be 9.8%.

Even during an average year, the impairment to total GDP in a 3,000 l/s scenario compared to the status quo would be 19%, while under a 1,500 l/s scenario the impairment would be 5.2%.

As identified earlier, the impairments to GDP calculated in this section are based around an assumption in Otago Regional Council's models of no long-term adaptive behaviour by farmers with regards to land use. Any such adaptation would likely reduce the impairments to GDP from those calculated.

Employment effects in Central Otago of changing minimum flows

The direct employment effects in Central Otago of changing minimum permitted flows are summarised in the following table.

Table 15

Direct employment in Central Otago from irrigated farms under different flows
Direct employment for each scenario

	Minimum flow scenario					
	Status quo	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Average year	180	176	170	163	154	145
Wet year	206	206	205	204	201	195
Dry year	126	120	112	98	75	54

The data shows that the impairment of direct employment in Central Otago from irrigated farms under their current land use would be a 35 job (19%) reduction in an average year under a 3,000 l/s minimum

flow level compared to the status quo. This impairment would reduce to 10 jobs (5.4%) at a 1,500 l/s minimum flow level.

The table also shows theoretical impairments to employment under wet and dry years. For reasons discussed earlier, these modelled employment effects are likely to overestimate year-to-year employment volatility under current land use. Nevertheless, they still help show the sense of direction and scale of effects between different minimum flow scenarios. For example, during dry years, the impairments to direct employment in Central Otago from irrigated farming in the Catchment under a 3,000 l/s minimum flow scenario would be 57% below its benchmark level, while even under a 1,500 l/s minimum flow regime direct employment would still be 11% down.

The downstream employment effects on supply chains and from household spending of higher minimum flow scenarios are also significant. These are summarised in the table below.

Table 16

Total employment in Central Otago from irrigated farms under different flows
Total employment (direct + downstream) under each scenario

	Minimum flow scenario					
	Status quo	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Average year	305	298	289	277	261	247
Wet year	346	346	345	342	336	327
Dry year	222	212	199	176	139	106

Calculations from the data shows that even during an average year, the impairment to Central Otago's total employment across both direct and downstream channels would be a 58 jobs (19%) reduction under a 3,000 l/s scenario compared to the status quo benchmark.

Wider effects on the region of changing minimum flows

On top of the impairments to direct and downstream activity in Central Otago from changing minimum permitted flows, there are also additional effects that accrue to the rest of Otago Region.

The following table summarises these total effects on economic activity in Central Otago compared to Otago Region.

Table 17

Total GDP under different minimum flows in the Catchment
Total GDP (direct + downstream) measured in $ millions for each scenario

		Minimum flow scenario					
		Status quo	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Central Otago	**Average year**	$27.8m	$27.2m	$26.3m	$25.2m	$23.9m	$22.6m
	Wet year	$31.4m	$31.4m	$31.2m	$31.0m	$30.5m	$29.6m
	Dry year	$20.7m	$19.8m	$18.6m	$16.6m	$13.3m	$10.3m
Otago Region	**Average year**	$33.4m	$32.7m	$31.8m	$30.6m	$29.1m	$27.6m
	Wet year	$37.6m	$37.5m	$37.4m	$37.2m	$36.6m	$35.6m
	Dry year	$25.1m	$24.1m	$22.8m	$20.5m	$16.8m	$13.5m

Calculations from the table show that if farmers do not adapt their land use, then in dry years under a 3,000 l/s minimum flows scenario there could be as much as a 46% total reduction to GDP in Otago

relative to the status quo benchmark. Under a 1,500 l/s scenario, the total GDP impairment would be 9.1%.

Even during average years, total GDP from direct and downstream channels across Otago would be 17% lower in a 3,000 l/s scenario compared to its status quo benchmark. In a 1,500 l/s scenario the total GDP decline would be a more modest 4.8% decline.

The potential for such large changes to economic yields, suggests that there will be tipping points where some farms and downstream businesses adjust their activities and models under which they operate.

The downstream employment effects on supply chains and from household spending of higher minimum flow scenarios are also significant across Otago. These are summarised below.

Table 18

Total employment from irrigated farms under different flows
Total employment (direct + downstream) under each scenario

		Minimum flow scenario					
		Status quo	**900 l/s**	**1,500 l/s**	**2,000 l/s**	**2,500 l/s**	**3,000 l/s**
Central Otago	**Average year**	305	298	289	277	261	247
	Wet year	346	346	345	342	336	327
	Dry year	222	212	199	176	139	106
Otago Region	**Average year**	375	368	357	344	327	312
	Wet year	424	424	422	420	413	403
	Dry year	278	267	252	226	185	147

Calculations from the table show that even during an average year, the impairment to Otago's total employment across both direct and downstream channels would be a 17% reduction under a 3,000 l/s scenario compared to the status quo benchmark.

Appendix – Farm-level financial inputs

The following tables provide a summary of farm-level financial data used in the economic analysis. The data has been given for each farming system on average across the catchment during dry, wet, and average rainfall years under the six minimum flow scenarios. This data is drawn from AbacusBio's models and align to the version of the model in Compass Agribusiness' 25 March 2021 peer review report.

Selected farm financials in average rainfall years

The following table shows EBITDA plus wages and salaries in an average rainfall year.

Table 19

EBITDA + wages and salaries in an average rainfall year
Selected farm-level financial data from AbacusBio, $ per hectare, irrigated average across Catchment

Flow scenario:	Dairy	Dairy support	Sheep/beef
Status quo	$3,611	$971	$456
900 l/s	$3,544	$942	$445
1,500 l/s	$3,459	$905	$428
2,000 l/s	$3,330	$852	$410
2,500 l/s	$3,178	$797	$383
3,000 l/s	$3,012	$764	$357

The following table shows total sales (i.e. of livestock and milk) in an average rainfall year.

Table 20

Total sales in an average rainfall year
Selected farm-level financial data from AbacusBio, $ per hectare, irrigated average across Catchment

Flow scenario:	Dairy	Dairy support	Sheep/beef
Status quo	$8,727	$1,898	$1,037
900 l/s	$8,704	$1,897	$1,034
1,500 l/s	$8,672	$1,897	$1,031
2,000 l/s	$8,614	$1,896	$1,027
2,500 l/s	$8,525	$1,896	$1,021
3,000 l/s	$8,441	$1,894	$1,015

Selected farm financials in wet rainfall years

The following table shows EBITDA plus wages and salaries in a wet rainfall year.

Table 21

EBITDA + wages and salaries in a wet rainfall year
Selected farm-level financial data from AbacusBio, $ per hectare, irrigated average across Catchment

Flow scenario:	Dairy	Dairy support	Sheep/beef
Status quo	$3,819	$1,086	$584
900 l/s	$3,817	$1,086	$584
1,500 l/s	$3,795	$1,082	$582
2,000 l/s	$3,779	$1,068	$578
2,500 l/s	$3,705	$1,051	$570
3,000 l/s	$3,565	$1,030	$557

The following table shows total sales (i.e. of livestock and milk) in a wet rainfall year.

Table 22

Total sales in a wet rainfall year *Selected farm-level financial data from AbacusBio, $ per hectare, irrigated average across Catchment*			
Flow scenario:	**Dairy**	**Dairy support**	**Sheep/beef**
Status quo	$8,758	$1,898	$1,090
900 l/s	$8,757	$1,898	$1,090
1,500 l/s	$8,752	$1,898	$1,090
2,000 l/s	$8,777	$1,898	$1,090
2,500 l/s	$8,757	$1,898	$1,090
3,000 l/s	$8,744	$1,898	$1,087

Selected farm financials in dry rainfall years

The following table shows EBITDA plus wages and salaries in a dry rainfall year.

Table 23

EBITDA + wages and salaries in a dry rainfall year *Selected farm-level financial data from AbacusBio, $ per hectare, irrigated average across Catchment*			
Flow scenario:	**Dairy**	**Dairy support**	**Sheep/beef**
Status quo	$3,283	$775	$171
900 l/s	$3,207	$717	$155
1,500 l/s	$3,129	$642	$127
2,000 l/s	$2,920	$534	$89
2,500 l/s	$2,634	$370	$12
3,000 l/s	$2,330	$249	-$53

The following table shows total sales (i.e. of livestock and milk) in a dry rainfall year.

Table 24

Total sales in a dry rainfall year *Selected farm-level financial data from AbacusBio, $ per hectare, irrigated average across Catchment*			
Flow scenario:	**Dairy**	**Dairy support**	**Sheep/beef**
Status quo	$8,618	$1,895	$945
900 l/s	$8,572	$1,895	$943
1,500 l/s	$8,602	$1,894	$937
2,000 l/s	$8,529	$1,893	$930
2,500 l/s	$8,366	$1,892	$916
3,000 l/s	$8,094	$1,887	$905