Klondyke Storage Proposal – Assessment of Economic Effects

Final report

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AERU
Agribusiness and Economics Research Unit
A Lincoln University Research Centre.
New Zealand's specialist land-based university.

Research to improve decisions and outcomes in agribusiness, resource, environmental and social issues.

The Agribusiness and Economics Research Unit (AERU) operates from Lincoln University providing research expertise for a wide range of organisations. AERU research focuses on agribusiness, resource, environment, and social issues.

Founded as the Agricultural Economics Research Unit in 1962 the AERU has evolved to become an independent, major source of business and economic research expertise.

The Agribusiness and Economics Research Unit (AERU) has four main areas of focus. These areas are trade and environment; economic development; non-market valuation, and social research.

Research clients include Government Departments, both within New Zealand and from other countries, international agencies, New Zealand companies and organisations, individuals and farmers.

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Executive summary

- Rangitata Diversion Race Management Ltd (RDRML) proposes to build a water storage facility at Klondyke in order to increase the reliability of irrigation supply to its shareholders, and to facilitate the development of additional irrigation within the boundaries of the schemes irrigated from the Rangitata Diversion Race (RDR). The proposed 53 million cubic metre storage pond could also ensure that a significant volume of water will be available for other uses including irrigation outside the RDR, initiatives such as Managed Aquifer Recharge, and other economic and recreational uses yet to be identified.
- The AERU at Lincoln University was commissioned to evaluate the potential contribution of the facility to the local and regional economies and the potential environmental and social impacts of the development. Data from previously published studies, in conjunction with data supplied by RDRML, and in a series of technical reports commissioned by RDRML, has formed the basis of the analysis.
- The average reliability of water supply to the RDR from the Ashburton and Rangitata rivers is 93 per cent over the entire irrigation season and 84 per cent when adjusted for distribution infrastructure losses. During the autumn period the adjusted reliability is estimated to be only 78 per cent.
- Estimation of the impacts of restrictions in the availability of water to the 75,000 hectares currently irrigated from the RDR irrigation has been undertaken by relating pasture production losses to losses in the value-added at the farm-gate. The potential value of increasing the reliability of supply to existing RDR irrigators has been estimated to be $33.5 million at the farm-gate in the average season. The total (direct, indirect and induced) impact on Canterbury Regional GDP has been estimated to be $52.3 million per annum.
- Although it has not been possible to estimate the impacts of the average irrigation restriction on profitability at the individual farm level, an estimate based on MPI farm monitoring data suggests that in the average season CFS on the average dairy farm would be between 19 and 35 per cent higher if irrigation supply were consistently reliable.
- If development of the remaining consented area within the scheme boundaries were facilitated by the development of the Klondyke storage facility an additional 19,155 hectares could be irrigated. This represents an increase of 11.4 per cent of the area reported to be irrigated in the Ashburton District in 2012. In the average season it has been estimated that the additional direct contribution to regional GDP from this area would be $43.3 million, and the total impact would be $64 million. A total of 584 jobs would be created in the region, of which 251 would be created on farms in the Ashburton District.

	Value at farm-gate	Total contribution GDP
Increased reliability:		
All existing irrigation area	$33.5 million/annum	$52.3 million/annum
Average dairy farm	19 – 35 % CFS increase	
Increased irrigation area	$43.3 million/annum	$ 64.3 million/annum

- Cost benefit analysis has not been undertaken as part of this study. However, the total development costs of the facility have been estimated to be $238 million and the additional costs of on-farm irrigation development approximately $82 million. It is expected that the costs of water supplied from the facility will be comparable with the costs of water supply from Lake Coleridge to Barrhill Chertsey Irrigation Ltd.
- RDRML has commissioned a number of technical assessments to identify the potential environmental and social impacts of the development, and to develop strategies to ensure

that these costs are avoided, mitigated or minimised. Many of the mitigations required are to be incorporated into the design of the facility, while others will be built into resource consent conditions, or other legislative requirements. With appropriate mitigations:

- The impacts on the visual landscape and natural character of the area are expected to be low to moderate, and mitigations have been designed to minimise these;
- There will be no impact on native birds, and impacts on both lizards and native vegetation will be mitigated by creating new lizard habitat and replacing native vegetation;
- The transportation effects will be acceptable. A traffic management plan has been developed and road maintenance monitoring recommended;
- Construction noise levels will not exceed levels specified as allowable in the Ashburton District Plan; and traffic noise levels will not exceed acceptable limits. A noise level monitoring strategy and a traffic management plan have been developed;
- Impacts on air quality will be less than minor. Smoke and dust management plans been developed and ambient dust and weather monitoring commenced;
- No significant risks to water quality as a result of potential discharges from the reservoir have been identified. There are no significant fauna or habitat present, and WCO conditions will be met with respect to water quality. Monitoring recommendations have been made;
- Groundwater impacts will be no more than minor. Specifications will be included in the construction plan and impacts will be managed under consent conditions;
- The impacts on the hydrology of the area will be less than minor;
- Provided the Dam Safety Guidelines are followed, the risk to people and property from a dam break "will be minimised to a very low level, which is consistent with international best practice for dam design, construction and operation".

- The estimated potential annual contribution to regional GDP of the proposed Klondyke storage proposal is expected to significantly outweigh the sum of social and environmental costs, and the mitigation expenses incurred in minimising these. In addition, although these have not been quantified:
  - Economic benefits may be generated by other users of the stored water for additional irrigation outside the RDR schemes or for uses yet to be identified, including Managed Aquifer Recharge;
  - Environmental benefits will be generated by the installation of a more effective fish screen to reduce the numbers of salmon and trout entering the RDR. Further benefits may be realised from the availability of stored water for MAR, and if the irrigation application rate is increased, reduced nutrient leaching as a result of greater uptake by plants;
  - Social benefits will be derived from the development of the white-water course,
- In addition RDRMLwas found to have taken a balanced approach in developing the proposal, which will not result in unacceptable outcomes for recreation in the Rangitata River catchment.
- The proposal has the potential to contribute directly to the CWMS targets of increasing the area developed for irrigation in the region and imprimproving the reliability of irrigation water supply for existing irrigators, without increasing pressure on the regions' freshwater resources. It also has the potential to contribute to the achievement of greater efficiency at the farm, scheme and catchment levels, because:
  - Higher returns associated with more reliable supply are likely to accelerate the trend towards the use of more efficient irrigation technology by existing irrigators;

- Certainty of supply means that irrigators will only use the water that they need (CWMS, 2009b);
- The efficiency of the distribution infrastructure will be improved if an additional 20,000 hectares can be developed within the area already consented for irrigation (i.e. a greater area supplied by existing infrastructure;
- The availability of storage means that a greater proportion of the water available throughout the year can be used without compromising environmental or other values.

However, it is unlikely that there will be increased incentive to develop a piped system for the area irrigated by MHIL, as a result of the proposed development.

Chapter 1
Introduction

1.1 Background

1.1.1 Canterbury Irrigation

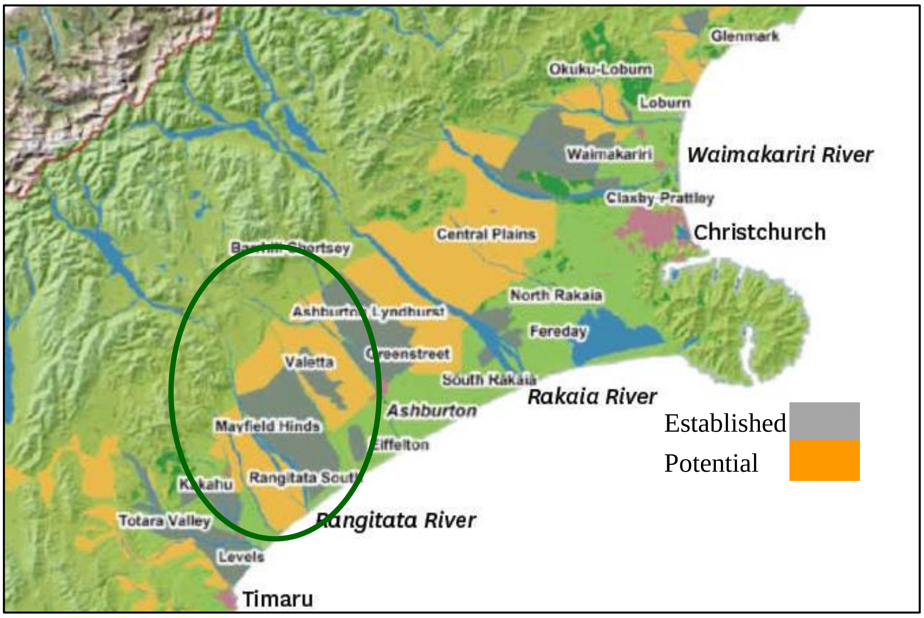
The potential contribution to New Zealand's economic growth objectives by the agricultural sector is widely recognised. In order to facilitate growth in the sector, the government has committed funding to support the development of irrigation infrastructure proposals to the 'investment-ready' prospectus stage, and support for strategic water management studies and community irrigation schemes. However, it is also recognised that agricultural growth cannot be achieved at the expense of the New Zealand environment, particularly of its freshwater resources. There is increasing concern about the impacts of land-use intensification as a result of irrigation development on water quality and ecological, cultural and recreational values.

Irrigation is of particular importance to the primary industries in Canterbury, since the region is dependent on irrigation during dry periods when it experiences relatively low rainfall, high temperatures, strong winds and, consequently, the highest potential evaporation deficit in the country (Canterbury Water, 2009a). The Canterbury Water Management Strategy (CWMS) sets out a framework for the environmentally sustainable management of the region's freshwater resources (Canterbury Water, 2009b). One of the targets of the CWMS is that by 2040 there will be 850,000 hectares of land irrigated with at least 95 per cent reliability in the region.

The most recent data on the area of land developed for irrigation in Canterbury (Statistics New Zealand, 2013) show that in 2012 the total area equipped for irrigation was 444,777 hectares, of which 89 per cent have been equipped with spray or micro irrigation systems, while the remaining 11 per cent have been developed for flood irrigation. A number of estimates of the potentially irrigable land in Canterbury have been proposed, although these areas are not known with certainty. Morgan (2002) assumed that the total area of irrigable land in Canterbury was 1.3 million hectares. Saunders and Saunders (2012), after examining GIS maps based on the New Zealand Land Resource Inventory, reduced this estimate to 1.1 million hectares. This suggests that there remain approximately 600,000 hectares of land that are potentially irrigable but as yet undeveloped.

A major impediment to increasing irrigation in Canterbury is that much of the regional freshwater resource is fully-allocated, or over-allocated, in relation to the limits imposed by Environment Canterbury (Ecan) and local communities, and there is no scope to draw more water from them than the levels already consented. Consequently, there will be an increasing need for the development of water storage infrastructure to allow water to be stored at times of peak flow, for distribution during the summer dry period (MfE, 2015). The vision for Integrated Regional Water Infrastructure in Canterbury identifies a proposal by Rangitata Diversion Race Management Ltd (RDRML) to develop a "storage option at Klondyke [that] could open up options to provide water into South Canterbury while also improving reliability in mid-Canterbury" as one of the avenues to achievement of the CWMS targets (Canterbury Water, 2009b).

The Rangitata Diversion Race (RDR) diverts water from the Rangitata River (30 cubic metres per second (m3/s)), and from the South Ashburton River (7 m3/s when available) to distribute to its shareholders. These include three community irrigation schemes (Mayfield Hinds (MHIL); Valetta (VIL); Ashburton Lyndhurst (ALIL)); two hydro-electric power stations at Montalto and Highbank; and the Ashburton District Council stockwater supply. It also supplies water to the Barrhill Chertsey Irrigation scheme (BCIL). RDRML is consented to irrigate 94,486 hectares within the boundaries of its three shareholding schemes, and at present approximately 75,000 hectares are developed for irrigation. The potential for a significant increase in irrigation development in the areas adjacent to the RDR schemes is identified in the CWMS and is shown in Figure 1 shows.



Source: Canterbury Water (2009a)

Figure 1: Potentially irrigable areas adjacent to the RDR.

Although the average proportion of the maximum consented water take available to the RDR is relatively high (93 per cent over the irrigation season), the demand for water is generally highest during the period when reliability is lowest. To increase the reliability of water supply to its shareholders, RDRML has evaluated a variety of water storage options during recent years. After consultation with stakeholders and commissioning a number of environmental and engineering investigations, the most favourable option has been found to be construction of a 53 million cubic metre (Mm3) storage pond (the Klondyke storage pond) approximately 10 kilometres downstream from the RDR intake, between the RDR and the Rangitata River. In addition a resource consent will be sought to increase the amount of water abstracted from the Rangitata River by 10 m^3/s. A facility of this size, in conjunction with the additional water take, is sufficient to irrigate the consented area of the RDR schemes (94,486 hectares) with 99 per cent reliability and leave a considerable volume of water for other users (PDP, 2016b).

Increasing the reliability of supply to existing irrigators and expansion of the irrigable area to 94,486 hectares, the area already consented for irrigation within the scheme boundaries, will require 14 Mm^3 if current irrigation application rates are maintained. If the application rate is increased to 0.52 L/s per hectare 36 Mm^3will be needed. This means that 17-39 Mm^3 is available for new/other irrigators, and for other uses including managed aquifer recharge (MAR). MAR is the artificial recharging of a targeted aquifer to help manage groundwater more sustainably by augmenting the recharge from natural processes such as rainfall and river seepage, as part of an integrated catchment system. MAR is not seen as a stand-alone approach to resolving water allocation issues, but in conjunction with other approaches, including greater irrigation efficiency and water storage, has been identified as a potential avenue to enhancing economic, environmental, and cultural values (Environment Canterbury, 2013).

As part of the construction a new fish screen to prevent native and introduced fish species from being drawn into the race to the greatest extent possible will be installed, and a white water course developed for recreational use when water is released to the Mayfield Hinds Irrigation Scheme. In addition to the storage pond RDRML intends to apply for resource consent to divert an additional 10 m^3/s from the Rangitata River during flood flows. Canal modifications to accommodate the additional flow will be undertaken as part of the construction project.

1.2 Purpose and scope of the report

To facilitate preparation of a resource consent application to build the storage facility and to abstract the additional water during flood flows, RDRML has commissioned a suite of technical reports on aspects of the construction and on the expected impacts of the development on a range of ecological, recreational and cultural values.

The AERU at Lincoln University has been commissioned to:

- Provide a robust and comprehensive description of the existing economy of Canterbury and the Ashburton District and the contribution of the agricultural sector to the local and regional economies;
- Assess the potential impacts of the proposed water storage facility and flood flow abstraction, and identify and quantify the measures needed to avoid, remedy or mitigate any adverse effects.

Chapter two describes the contribution of agriculture and irrigation to the economies of Canterbury region and the Ashburton district, and summarises the studies that have been conducted into the value of increased irrigation development and increased reliability of irrigation to existing irrigators in the region. The economic benefits from the development of the Klondyke storage facility are discussed in Chapter three, and the potential environmental and social costs and benefits associated with this development are described in Chapter four. The conclusions from the research are presented in Chapter five.

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Chapter 2
The economic contribution of agriculture and irrigation to the regional and district economies

2.1 Economic contribution of irrigation

2.1.1 Contribution to the Canterbury regional economy

Agriculture is a significant contributor to the regional economy of Canterbury, directly contributing 6.1 per cent of regional Gross Domestic Product (GDP) in 2013 ($1,712 million) compared with the national contribution of 4.2 per cent (MBIE, 2015). Canterbury contributed 18.6 per cent of the national GDP from agriculture. Agriculture, fishing and forestry jointly accounted for 6.5 per cent of regional employment during that year.

Expenditure flows from farms and the flow-on expenditure from services provided to farms by rural businesses also have a significant impact on economic activity in Christchurch City. Guenther et al. (2015) estimated that expenditure flows from the two districts closest to the city (Selwyn and Waimakariri) accounted for $3.9 billion of the value of output of Christchurch (13.6 per cent). While the contribution of districts further from the city, including Ashburton district, was not estimated, it was recognised that the total contribution from agriculture to the city would be significantly higher than 14 per cent.

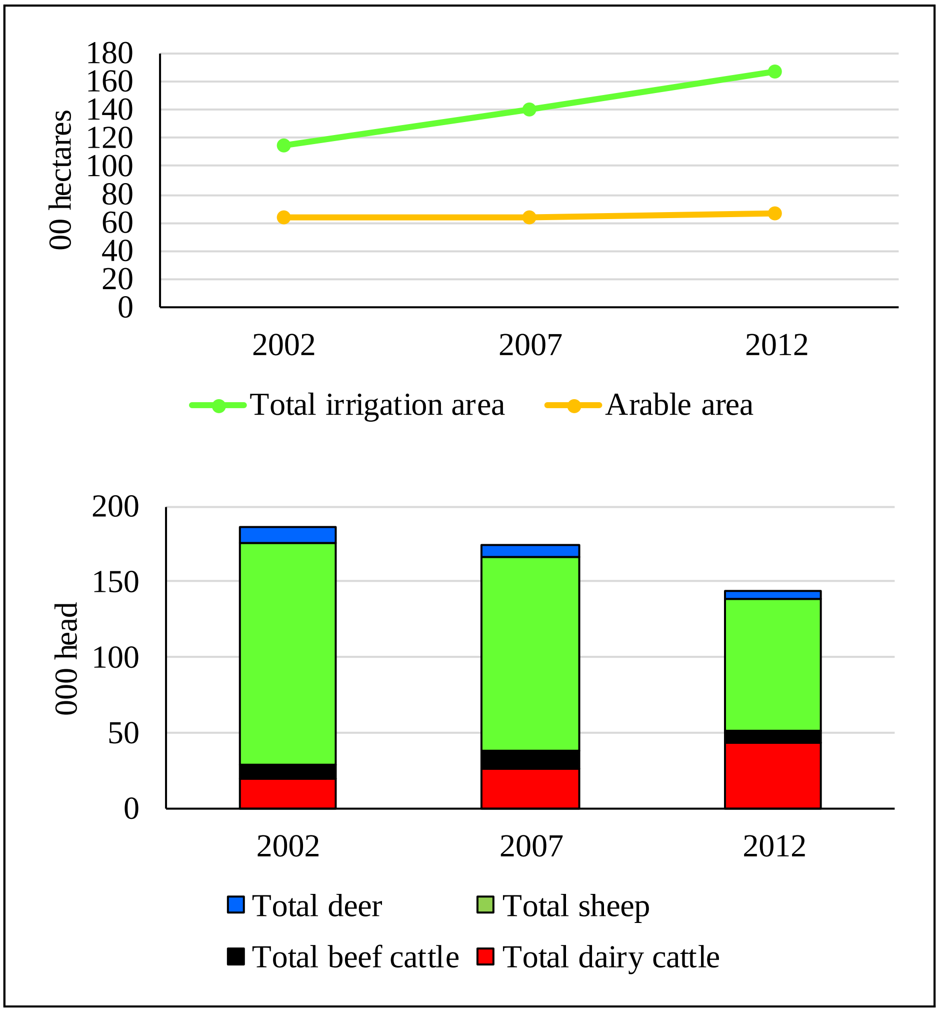
It has been estimated that in 2011/12 the contribution of irrigation in Canterbury to GDP was $1,394 million dollars per annum, which accounted for 64 per cent of the total farm-gate value of irrigation in New Zealand (Corong, et al., 2014). In 2011/12 the GDP of the Canterbury region was $26,516 million, to which agriculture contributed $1,939 million (7.3 per cent) (Statistics New Zealand, 2015), which suggests irrigation accounted for five per cent of regional GDP, and 72 per cent of regional agricultural GDP in that year.

2.1.2 Economic contribution to the economy of Ashburton District

Agriculture is the single largest contributor to GDP in the Ashburton District (33.2 per cent in 2012) (MBIE, 2015). In 2012, dairying alone accounted for 20 per cent of the district's GDP, while sheep, beef and arable farming accounted for nine per cent, and other types of farming for less than one per cent (sourced from Infometrics Quarterly District GDP Monitor, Rob Brawley, Grow mid-Canterbury, pers. comm.).

The pattern of agricultural production in the district has changed rapidly over the last decade (as Figure 2 shows) with a marked increase in dairying as a result of the increasing area under irrigation (144,875 to 167,890 hectares). Community irrigation schemes supplied by the RDR account for 40 per cent of that area. Dairy cattle numbers have increased by 128 per cent and sheep numbers have declined by 41 per cent during the period 2002-2012. The area of arable production has increased by only four per cent during that time.

In 2015, 17.4 per cent of the workforce in Ashburton district was employed on 1,647 farms. Dairy properties (550) employed 60 per cent of the agricultural workforce and sheep beef and grain farms (825), employed 29 per cent (Statistics New Zealand (2015b). Another 9.4 per cent of the total district work force was employed in food processing industries, which purchase a large proportion of inputs from farms (Statistics New Zealand (2015b).



Source: Statistics New Zealand (various years)

Figure 2: Agricultural land use and production Ashburton District 2002-2012

The net direct contribution to GDP of Canterbury irrigation estimated by Corong et al. (2014) is equivalent to $3,134 per irrigated hectare per year (in 2011/12 dollar terms). Extrapolation from the regional average to the current area of irrigation in the Ashburton District suggests that the annual farm-gate value of irrigation in the district is approximately $526 million, and that the schemes irrigated from the RDR account for more than $200 million (almost 40 per cent). In the context of the total agricultural contribution to GDP of $589 million (MBIE, 2015) this estimate appears to be high, but irrigation is clearly extremely important to the district's economic performance.

The Ashburton District Council acknowledges that "access to and use of water is the single biggest issue" faced by the district (Ashburton District Council, 2014a). The district's water systems are the basis of its strong agriculturally-based economy, and much of its agricultural production is reliant on continued availability of irrigation water. The rural plains of the district, where irrigation development is concentrated, cover approximately half the area of the district (335,000 hectares) (Ashburton District Council, 2014b).

2.2 The regional values of irrigation development and changes in irrigation reliability

Since 2000, the ***economic value of irrigation development*** in Canterbury to local, regional and the national economies has been examined in a number of studies. The most recent and most relevant of these are reviewed in this section. More recently, studies by Harris Consulting (2012a; 2012b) and Olubode-Awosola et al (2013) have examined the potential economic impacts of changes in the ***reliability*** of irrigation for existing irrigators.

2.2.1 Irrigation development

Harris et al. (2004) conducted a regional economic analysis of the uses of water for additional irrigation or hydro-electric power generation in the Waitaki catchment. The "region" defined for economic impact analysis was the area in North Otago and South Canterbury included in the local government jurisdictions of the Waitaki, Waimate, Mackenzie and Timaru districts. The study used two complementary forms of economic analysis in order to examine the impacts of potential water allocation rules. These were cost benefit analysis, which compares the streams of benefits and costs associated with an investment over time in order to derive a net present value (NPV), and economic impact analysis, which examines the impacts of a new activity on the gross output, value-added (contribution to Gross Domestic Product (GDP)), and employment in the affected region. Several irrigation scenarios, as well as the development of new hydro-electric power generation capacity, were evaluated.

As the relationship between irrigation and hydro-electric development had a very significant impact on the results of the cost benefit analysis, this analysis is not relevant to the proposed Klondyke development. The economic impact analysis of irrigation development without further hydro-electric development showed that, once irrigation development was complete, an additional $181.9 million of agricultural output would be generated annually. The total (direct, indirect and induced) contribution to value-added (GDP), once development was completed, from undertaking irrigation development that would provide water to 124,250 hectares was estimated to be $176 million per annum or $1.42 million per thousand irrigated.

In an ex-post analysis of the impacts of irrigation from the Opuha Dam in South Canterbury, Harris et al (2006) found that revenue was 2.4 times as high on irrigated farms (on which an average of 49 per cent of effective area was irrigated) than on similar dryland properties. For each additional thousand hectares of irrigation developed, the total (direct, indirect and induced) additional value-added (GDP) in the local economy of Timaru and the Fairlie Basin was estimated to be $2.53 million per annum ($3.10 million in 20-14/15 terms). Thirty jobs were created in the local economy per thousand hectares irrigated.

The potential economic impacts of irrigation development on the Hunter Downs in South Canterbury were assessed by (Butcher, 2007 cited in Butcher, 2014)) under two irrigation reliability scenarios. In this analysis the increase in value-added at the farmgate per thousand hectares irrigated was found to increase by 1.1 million per thousand hectares irrigated with reliable irrigation supply, and 0.5 million under less reliable irrigation supply. The total (direct, indirect and induced) increases were estimated to be $3.0 million and $1.8 million respectively, while the total increases in regional employment associated with the development were estimated to be 30.7 FTEs (reliable irrigation) and $17.9 FTEs (less reliable irrigation.

Butcher (2009) summarised the results of an economic analysis of the proposed development of 25,000 hectares of irrigation in the MacKenzie Basin, and updated the analysis in evidence given to the hearing on the resource consent applications to take water from the Waitaki River for this purpose. He found that the increase in total (direct, indirect and induced) value-added in the Waimate, Waitaki and MacKenzie Districts would increase by $53 million per year, or

$2.12 million per thousand hectares irrigated. The total increase in employment was estimated to be 470 FTEs or 18.9 FTEs per thousand hectares irrigated.

Saunders and Saunders (2012) estimated the total potential benefit of irrigation of large-scale irrigation developments in Canterbury on both the regional and national economies. They tested three irrigation scenarios reflecting the development of all the undeveloped potentially irrigable land in Canterbury (607,773 hectares); 60 per cent of the undeveloped potentially irrigable land (364,664 hectares); and an estimate of potential demand for irrigation provided in the CWMS (250,000 hectares) (Canterbury Water, 2009b) over the period 2014-2031. Their analysis showed that by 2031 each additional thousand hectares irrigated would contribute $4.46 million per annum to regional GDP (including direct, indirect and induced effects). At the farm-gate the additional value-added was estimated to be $2.98 million per thousand hectares irrigated. The prices used in this analysis were derived from the Lincoln Trade and Environment Model and were reported in graphic form, which suggests that the producer prices for dairy and arable products used were only marginally lower than the base year (2010/11 prices), while a greater decline in prices was forecast for both sheep and beef products.

Corong et al. (2014) conducted an economy-wide assessment of the value of irrigation to New Zealand. The value-added estimates from this study included the direct effects of irrigation at the farm-gate on a regional basis. The total contribution once the induced and indirect effects have been accounted for was estimated only at the national level. The direct contribution of irrigation in Canterbury estimated to be $3.13 million dollars per thousand hectares irrigated per annum in 2011/12 dollar terms ($1,394 million in total), while the national contribution was estimated to be $2,175.8 million per annum (or $3.02 million per thousand hectares irrigated). The product prices used in the analysis were the prices used in the MPI farm monitoring budgets for the 2011/12 year.

These analyses are not directly comparable because of the diverse range of assumptions on which they are based, including assumptions about methods and reliability of irrigation, the location and, therefore, productive capacity of the land to be irrigated, and land-uses, etc. The results have been converted to 2015 values using the New Zealand GDP deflator (OECD, 2015) and the contribution of each 1,000 hectares irrigated to regional GDP and employment summarised in Table 1.

Table 1: Summary of the economic contribution of the development of 1,000 hectares of irrigation to the regional economy

Study	Value-added $million	Employment (FTEs)
Total (direct, indirect, induced)		
Harris et al. (2004)	1.9	31.7
Harris et al. (2006)	3.1	30.0
Butcher (2007)	1.8 - 3.0	17.9 - 30.7
Butcher (2009) (district level)	2.4	19.9
Saunders and Saunders (2012)	4.5	31.4
Farm-gate		
Butcher (2007)	0.5 - 1.1	5.8 - 11.4
Canterbury Water 2009b	1.8	
Saunders and Saunders (2012)	3.2	
Corong et al (2014)	3.3	

2.2.2 Increased reliability of irrigation

Several studies of irrigation developments that would affect the reliability of the supply of irrigation water to existing irrigators in Canterbury have been published in recent years. Reliability of supply has been defined as "the restrictions and water availability an enterprise can expect" (Lincoln Environmental, 2001). Restrictions can be described in terms of their:

- Severity (the proportion by which unrestricted supply is reduced);
- Frequency (the number of times in a season when supply will be restricted and the number of seasons in which restrictions apply);
- Duration (the length of time the restriction is applied);
- Timing (the stage of the irrigation season at which the restriction is in place) (Harris et al., 2012).

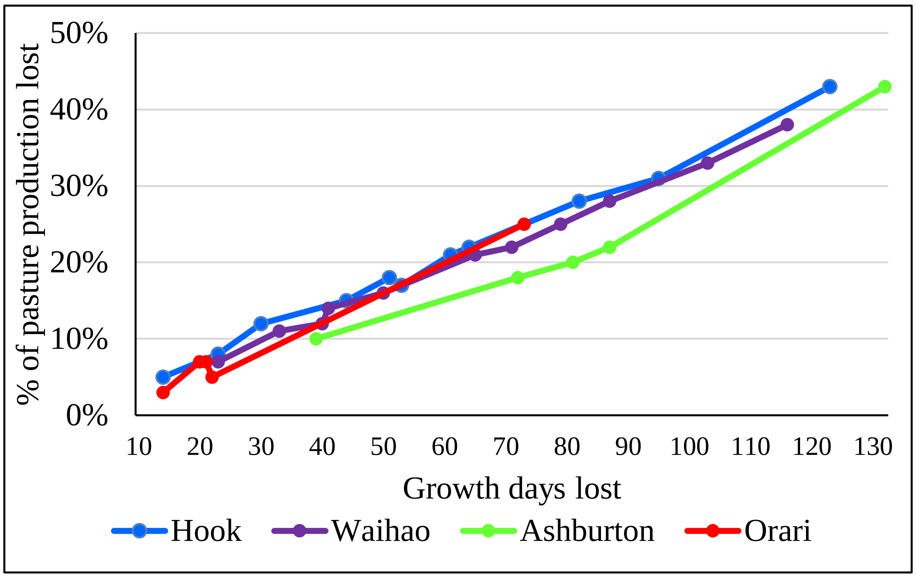
A series of assessments has been undertaken, using the same methodology, of the economic impacts of changes in the reliability of irrigation associated with changes in the flow regimes and allocation rules for several Canterbury rivers. In the first Harris et al. (2012) examined the impacts of changes in irrigation reliability on Ashburton River irrigators. Harris Consulting (2012; 2012b) evaluated several reliability scenarios on farms irrigated from two South Canterbury rivers, the Waihao and the Hook; and Harris Consulting (2013) conducted as similar analysis of changes in minimum flows proposed for the Orari River in South Canterbury.

The methodology employed in these studies related the severity of the restrictions expected to occur under different scenarios (categorised as less than 10 per cent available; 10 to 50 per cent available; 50 to 100 per cent available) to the expected losses in pasture dry matter production under the differing levels of restriction. The weighted average daily pasture production at different times in the irrigation season in the absence of restrictions was estimated from pasture production data recorded on the Lincoln University dairy farm (LUDF).

If irrigation was restricted by 50 per cent or more, the reduction in daily production was assumed to be 85 per cent of average daily production while restrictions of 0 to 50 per cent were assumed to result in pasture production losses of 25 per cent. Despite the differences in the timing of restriction under differing scenarios for each river, the relationships between the estimated days of irrigation lost and the total reduction in pasture dry matter are relatively consistent amongst the Orari (three year and current scenarios), Waihao and Hook river catchments. However, production losses per growth day lost were lower for irrigators from the Ashburton River. These relationships are shown in Figure 3.

Total pasture production lost was then related to the outputs from the farm types in the areas affected by the restrictions using:

- A standard ratio of milk solids production to pasture dry matter production (1:11);
- The relationship between crop production and irrigation loss (0.05 per cent per day of irrigation lost);
- The amount of pasture DM required to support sheep and beef stock units.



Sources: Harris et al, 2012
Harris Consulting 2012a, 2012b, 2013

Figure 3: Growth days and pasture production lost, Waihao, Hook, Orari and Ashburton rivers

Production losses were related to farm financial performance using the Ministry of Agriculture and Forestry (now Ministry for Primary Industries (MPI)) farm monitoring data, which were last published in 2012. As expected, the results of these analyses differ markedly among the restriction scenarios, land-use, and river catchments analysed, but in all cases the losses in total revenue are directly aligned with the losses in pasture production. As an example Figure 4 shows the relationships between financial impacts, pasture production losses and growth days lost for the Ashburton dairy farm model under a range of flow regime scenarios (Harris, et al., 2012).

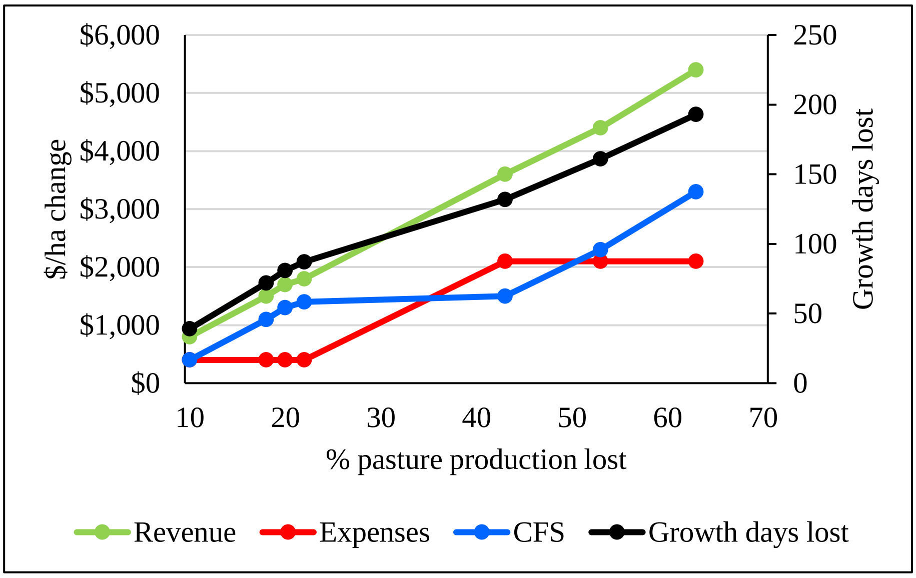


Figure 4: Financial performance, pasture production losses and growth days lost – Ashburton dairy farm model.

Olubode-Awosola et al. (2013) assessed the regional economic impacts of changes in the reliability of irrigation water in the Hinds catchment by estimating the value of lost pasture production under differing levels of irrigation reliability. A socio-economic accounting matrix input-output model was used to estimate the impacts of pasture production losses on regional GDP and employment. The value of increasing supply reliability on areas supplied by water from four different sources, BCIL (4,500 hectares; average reliability = 50 per cent); Valetta groundwater (3,200 hectares; average reliability = 80 per cent); Hinds River surface water (300 hectares; average reliability = 40 per cent); lowland drains surface water (3,300 hectares; average reliability = 80 per cent). The estimated gains in regional GDP per 1,000 hectares irrigated, associated with increases in irrigation reliability, are shown in Figure 5.

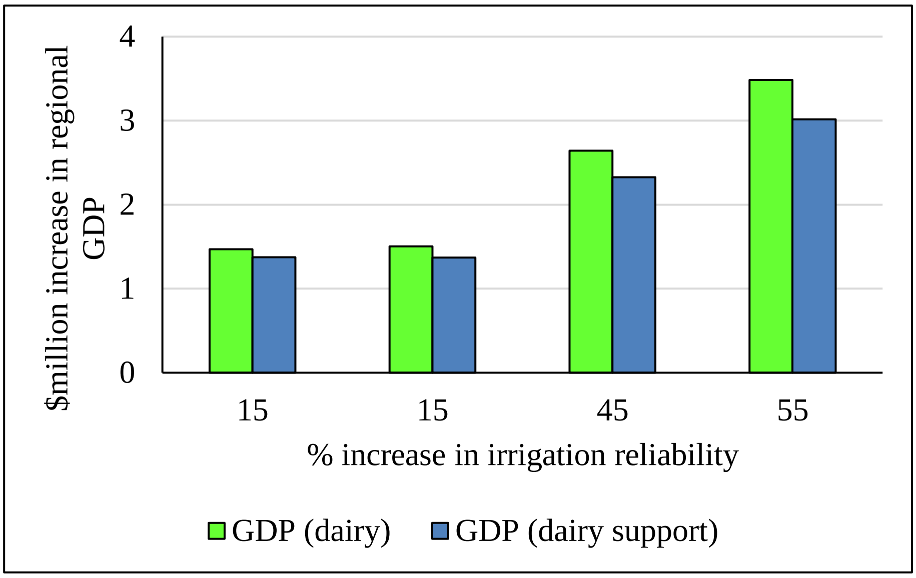


Figure 5: Increases in contribution to regional GDP ($ million) with changes in irrigation reliability

Changes in regional employment levels as a result of increases in irrigation reliability are shown in Figure 6.

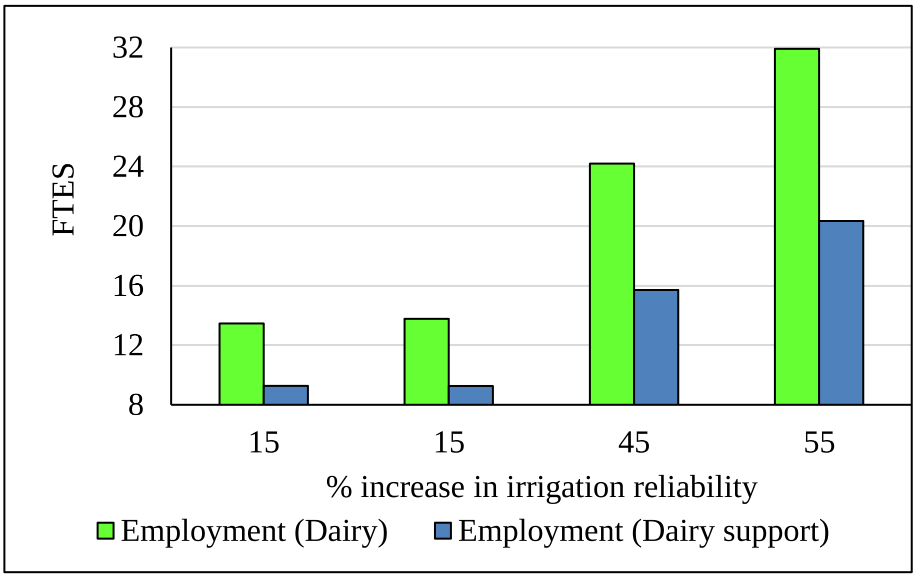


Figure 6: Increases in contribution to regional employment with changes in irrigation reliability

Chapter 3
The potential economic impacts of the Klondyke storage development

The Klondyke storage proposal has been put forward by RDRML, after preliminary consultation with stakeholders and interested parties, with the objectives of:

- Improving the reliability of irrigation for existing RDRML shareholders taking water from the RDR;
- Supplying sufficient water to facilitate further irrigation development in mid-Canterbury and/or allow RDRML to supply irrigators in South Canterbury with water from the RDR;
- Providing a physical tool to assist in achieving regional water targets and outcomes by artificial recharge of groundwater by using MAR or Targeted Steam Augmentation (TSA) (RDRML, 2016).

The studies described in Chapter 2; information contained in the technical reports commissioned by RDRML; and data provided by RDRML and others have been used as a basis for estimating the likely scale of the potential economic benefits of increasing the reliability of irrigation; expansion of the area irrigated from the RDR; and other potential water uses.

3.1 Impacts on the reliability of irrigation

The reliability of irrigation depends on both the supply of, and demand for, water for irrigation. The amount of water actually available at the farm-gate depends on the availability of water at source and the efficiency of the distribution infrastructure, while the effectiveness of irrigation depends on the efficiency of irrigation application technologies, as well as on the irrigation management practices employed on-farm. The analyses of the reliability of irrigation schemes summarised in Chapter 2 have been based on actual data on water extracted for irrigation over time. The data available on the RDR irrigation schemes do not include actual data on water takes, but are restricted to monthly data on the proportion of the maximum take available for abstraction from the rivers. In addition, modelling work undertaken as part of the Klondyke storage feasibility assessment has included supply and demand modelling of the reliability of irrigation of differing land areas under a number of storage scenarios. All of these included the assumptions that water would be conveyed by piped races and applied using spray technology, which is not the case at present.

3.1.1 Water availability from the RDR

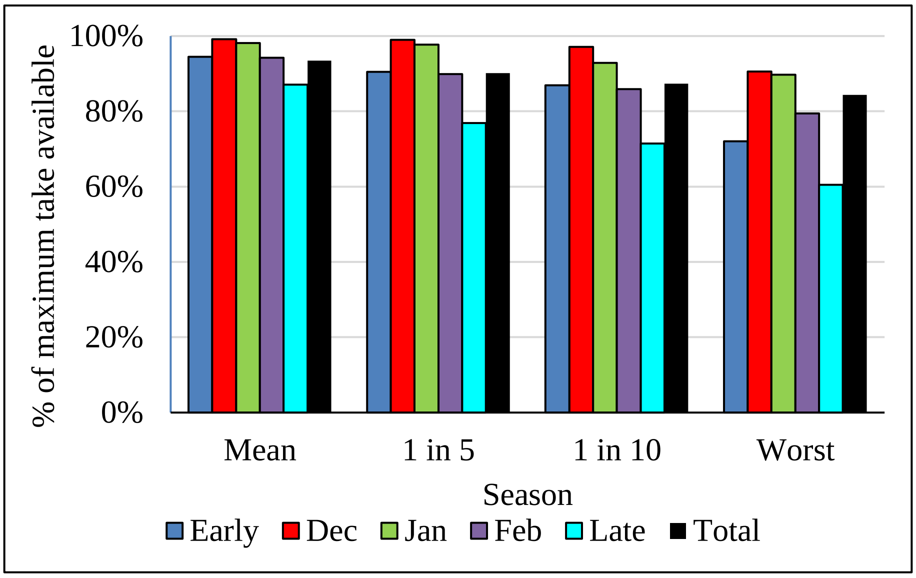
The consented water take available to the RDR is 30.7 m^3/s from the Rangitata River and 7.1 m^3/s from the Ashburton River, with a combined total of no more than 35.4 m^3/s. The water take from the rivers is limited by minimum low flows imposed by resource consents to meet the requirements of the Rangitata Water Conservation Order (WCO) (Water Conservation Order (Rangitata River), 2006) and the Ashburton River minimum flow regime (Ecan, 2011). In addition, a number of RDR irrigators supplement the water supplied by irrigation schemes with on-farm storage.

The monthly data on the proportion of the maximum take that has been available to the RDR have been recorded for the seasons from 1979-80 to 2014-15. Overall, the availability of supply from the RDR is high; 93 per cent on average over the whole irrigation season, but only 87 per cent during the autumn months of March and April. However, in all years there has been at least some period of restricted supply, and in 86 per cent of years restrictions have occurred in five or more months of the season. The average restriction is considerably higher during the autumn months of March and April (13 per cent) than in other months. In the worst year experienced, water availability was restricted to 84 per cent of the maximum available take. These data are summarised in Table 2 and Figure 7.

Table 2: Actual availability (% of maximum allowable take) of water for irrigation from the RDR (1979/80 – 2014/15)

Season	Early season (Sep-Nov)	Dec	Jan	Feb	Late season (Mar-Apr)	Whole season
Average season	95%	99%	98%	94%	87%	93%
1/5 season	90%	99%	98%	90%	77%	90%
1/10 season	87%	97%	93%	86%	71%	87%
Worst season	72%	91%	90%	79%	61%	84%

Source: Ben Curry, CEO RDRML, pers. com.



Source: Ben Curry, CEO RDRML, pers. com.

Figure 7: Actual availability of irrigation water (% of maximum allowable take) from the RDR 1970/80 to 2014/15

Valetta Irrigation Ltd (VIL), which is the smallest of the three community scheme shareholders in the RDR (11,000 hectares), is now fully piped, and work is currently underway on piping the Ashburton Lyndhurst Irrigation Ltd (ALIL, 28,000 hectares). In future, distribution system losses in these schemes will be minimal. However, the largest scheme, Mayfield Hinds Irrigation Ltd (MHIL, 36,000 hectares), is an open-race system which incurs losses to groundwater of 3.3 m^3/s (20 per cent) of the 16.5 m^3/s (20 per cent) allocated to it. This represents a reduction of 9.3 per cent in the volume of water available to all RDR irrigators.

The irrigation application methods employed by RDR irrigators have changed in recent years from relatively inefficient borderdyke systems to spray and micro systems. In the MHIL area only 3,000 hectares (10 per cent) are now irrigated by borderdykes, and this system is no longer used by irrigators in the VIL (Hamish Tait, MHIS General Manager, pers. comm.). In the ALIL area, 30 per cent of the area (9,000 hectares) remains under borderdykes and approximately seven per cent of shareholders have been converting to spray irrigation annually (ALIL, 2015). In total spray and microsystems are employed on approximately 82 per cent of the combined scheme area.

In the absence of data on the actual water take from the RDR, an estimate of the proportion of the 35,400 m^3/s water available from the RDR that is available to RDR irrigators has been made by reducing the levels shown in Table 2 by 9.3 per cent to account for losses in the MHIL distribution system. No allowance has been made for losses in the ALIL infrastructure since work is already underway on piping this scheme. The results of this analysis are shown in Table 3 and Figure 8. Under these assumptions irrigators would have access to 84 per cent of the 35,400 m^3/s consented water take over the whole of the average irrigation season, while in the autumn only 78 per cent would be available in the average season.

Table 3: Availability of irrigation water (% of maximum allowable take) from the RDR 1970/80 to 2014/15 adjusted for distribution infrastructure losses

Season	Early season	Dec	Jan	Feb	Late season	Whole season
Average season	85%	90%	89%	85%	78%	84%
1/5 season	81%	90%	88%	81%	68%	81%
1/10 season	78%	88%	84%	77%	62%	78%
Worst season	63%	81%	80%	70%	51%	75%

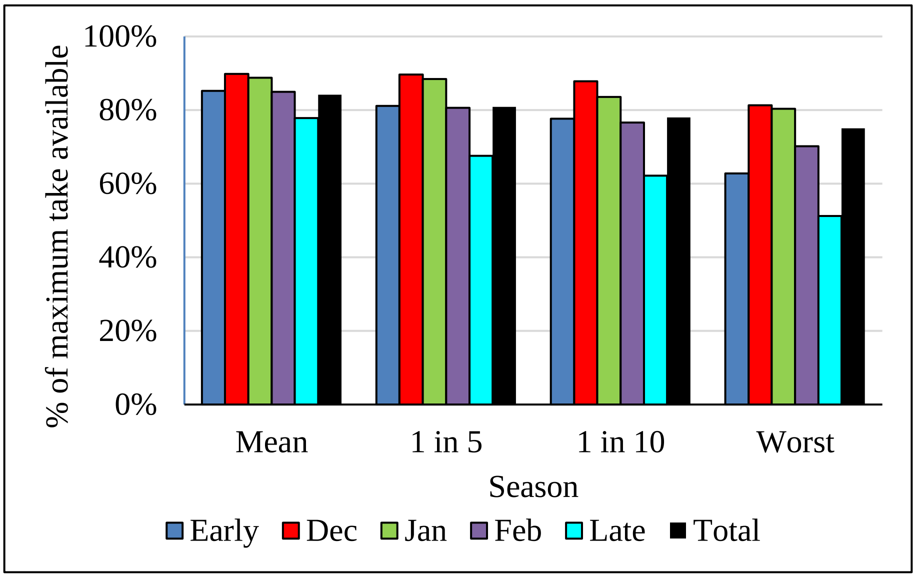


Figure 8: Availability of irrigation water (% of maximum allowable take) from the RDR 1970/80 to 2014/15 adjusted for distribution infrastructure losses

These losses have been estimated on the assumption that landuse would be unchanged by increased reliability of irrigation. In fact it is probable that the increased reliability of pasture production, and the increased certainty with which farm budgets could be prepared, would encourage some existing irrigators to intensify production, converting from sheep and beef production to dairy, high-value arable or other intensive systems.

This analysis has not taken account of the fact that a number of irrigators in the area have developed on-farm storage ponds to augment the supply available from the community schemes, since the extent to which this influences the average reliability of irrigation is not known.

3.1.2 Future irrigation reliability

While the reliability of the supply of water for irrigation from the Rangitata and Ashburton Rivers is, on average, relatively high under current water allocation rules, significant changes to minimum flows from the Ashburton River are to be imposed in 2023 and 2033 (Paddle Delamore Partners (PDP, 2016a). De Joux (2013), in evidence given at the Canterbury Land and Water Regional Plan hearings, reviewed data available from the Horrell flow model, developed to assist Environment Canterbury in determining a flow regime for the Ashburton He reported that:

> "The Horrell flow model shows that the recorded (residual) flow for the Ashburton River at State Highway 1 Bridge for the period June 1996 to November 2011 was at 6,000 L/s for 54 per cent of the time and was at 10,000 L/s for 37.5 per cent of the time, a difference in time of 16.5 per cent. Although detailed modelling would be required to confirm the change in reliability, it seems that a reduction in the order of 16 per cent may be required."

Although no further detail on the seasonal distribution of restrictions that will be necessary when the Ashburton River minimum flow levels are raised, data presented by Horrell (2004) suggest that the most serious restrictions would be required during the later part of the irrigation season, during which restrictions are most severe under the present flow regime.

In addition to changes in flow regimes, climate change is expected to exacerbate water restrictions in future. MfE (2011) has summarised the expected impacts of climate change on Canterbury as:

- Less annual rainfall;
- Decreased run-off to rivers;
- Increased evaporation;
- Increased frequency and severity of drought;
- Increased irrigation demand.

O'Donnell (2007) reported that by the 2030s, even under "the most benign" assumptions, drought effects will be more common and it is suggested that the frequency of 1 in 20 year droughts will increase to 1 in every 10 to 15 years. Under a more extreme scenario they may occur four times as frequently. With climate change it is expected that there will be increasing winter rainfall in the Southern Alps, and a reduction in snowfall. Consequently, with less snowmelt there will be less water in alpine rivers in late spring/early summer, and more during winter as a result of increased rainfall. The author concluded that water storage, as a component of irrigation schemes, will be increasingly vital for security of supply.

3.1.3 Supply-demand modelling of irrigation reliability

RDRML has commissioned modelling of a number of storage scenarios to assist in determining the optimal size of the proposed storage facility. The models used accounted for both the supply of, and demand for, irrigation; estimated changes in the reliability of irrigation for existing irrigators; and calculated the areas of additional information possible under a range of storage scenarios.

<u>*75,000 hectares irrigated no storage:*</u>

The current situation was not modelled as part of this analysis. Instead the baseline analysis reflected the reliability of irrigation when all potential improvements to the efficiency of the distribution infrastructure and on-farm application technology have been achieved, i.e. the currently irrigable areas (75,000 hectares) would be irrigated using spray irrigation technology with piped distribution but no storage. In this scenario, the irrigation reliability in the average season would exceed 99 per cent. In the worst season average reliability would be 95 per cent. The results of this modelling are shown in Table 4.

Table 4: Modelled irrigation reliability 75,000 hectares, no storage (1979/80 – 2014/15)

	Early season	Dec	Jan	Feb	Late season	Whole Season
Average season	99.78%	99.36%	99.83%	99.29%	99.18%	99.52%
1/5 season	99.80%	99.20%	99.88%	98.34%	98.05%	99.04%
1/10 season	99.31%	98.12%	99.52%	97.36%	97.09%	98.80%
Worst season	97.93%	96.80%	97.70%	96.30%	95.30%	98.10%

Source: PDP (2014)

This analysis suggests that gains in reliability, similar to those achievable if stored water were available, could be achieved by RDR's existing shareholders by mean of upgrading both the distribution infrastructure and on-farm irrigation technologies used. However a number of factors were not included in this analysis, including:

- The proposed changes to occur in the Ashburton River Flow regime, and/or the eventual loss of the Ashburton River as a source of water for the RDR;
- The irrigation application rates used in the model were the current application rates in the three RDR schemes, which are low (0.41 L/s/ha on average) compared with the rates usually required in Canterbury where evapo-transpiration rates are extremely high during the peak irrigation season.
- Considerable capital expenditure both on and off-farm would be required before the irrigation efficiencies included in the analysis could be achieved. In order to meet these capital requirements, farmers could be expected to intensify their existing farming operations, increasing the contribution of the irrigation to local and regional GDP, but also increasing their vulnerability when restrictions do occur. Mayfield Hinds irrigators rejected a proposal to pipe the scheme at a cost of $135 million in 2014 (Bishop, 2014). It had been expected that the proposal would not pay off until 2053.
- Changes in the regulatory rules imposed by the Canterbury Regional Land and Water Plan are likely to mean that the additional irrigation development needed to pay for this proposal may not be feasible in future.

Consented area (95,000) hectares irrigated no storage:

Although the current area irrigated by the RDR is only 75,000 hectares, the total consented area of the three schemes is 94,486 hectares (PDP, 2016). The second scenario evaluated by PDP was the supply of water to the whole consented area by means of piped distribution and spray application. As Table 5 shows, the whole-season reliability of irrigation would decline to 95 per cent, with the greatest restriction occurring from December to February.

Table 5: Modelled irrigation reliability 95,000 hectares, no storage (1979/80 – 2014/15)

	Early season	Dec	Jan	Feb	Late season	Whole Season
Average season	96.65%	91.25%	92.92%	93.21%	96.63%	95.08%
1/5 season	94.82%	84.62%	89.16%	87.42%	92.94%	92.55%
1/10 season	94.18%	82.78%	86.58%	85.48%	91.81%	91.84%
Worst season	92.97%	79.80%	81.80%	83.00%	86.00%	90.87%

Source: PDP (2014)

Potential future irrigation development using water from the proposed storage facility:

In addition to these two scenarios, PDP (2016) also evaluated the extent to which the proposed storage facility could facilitate additional irrigation development, if the regulatory environment allowed. They found that:

- If the irrigation application rate were increased to 0.52 L/s per ha and 53 Mm^3 of storage developed 101,400 hectares could be irrigated from the RDR;
- If the current irrigation application rate were retained and 53 Mm^3 of storage developed 110,000 hectares could be irrigated from the RDR.

The economic impact of this development has not been evaluated for this report since, since it is not possible to determine where, or to what extent future development will be possible under the current regulatory environment.

3.1.4 The value of increased reliability of irrigation

The modelling commissioned by RDRML shows that under the Klondyke storage proposal, in conjunction with the supplementary water take of $10m^{3/}s$, existing RDR irrigators will be assured of irrigation reliability of at least 99 per cent throughout the irrigation season.

In order to estimate the potential value of increased reliability of irrigation, the reductions in pasture and livestock production and the resulting impacts on farm profitability have been examined under the assumptions that:

- Irrigation reliability equals the proportion of maximum take available for abstraction. For the piped VIS and the ALIS areas, which will be piped in the short-term, irrigation reliability is assumed to be the same as the proportion of maximum take while reliability of irrigation to MHIS irrigators is estimated to be the proportion of maximum take available adjusted for the losses associated with the distribution system for that scheme.
- The pattern of landuse will remain unchanged from existing levels, which were reported by PDP (2016). These are shown in Table 6. The analysis of the current situation is based on the data on irrigation supply presented in Table 2 and Table 3 (pp 13 and 14).

Table 6: Proportional land use in areas of irrigation schemes supplied by the RDR.

Scheme	Dairy	Dairy support	Sheep/ Beef	Arable	Other	Total
MHIL	59.9%	20.0%	8.7%	9.8%	1.6%	48.0%
VIL	69.4%	21.5%	4.8%	1.5%	2.8%	14.7%
ALIL	46.6%	17.8%	14.9%	19.5%	1.2%	37.3%
Total	56.3%	19.4%	10.4%	12.2%	1.6%	100.0%

The Harris reliability analyses estimated the loss in pasture production as:

Irrigation days lost *Weighted average pasture growth = Total pasture growth lost

A similar approach has been taken in the current analysis with weighted average growth calculated as the average growth during the period on the Lincoln University Dairy Farm (Ron Pellow, SIDE, pers. comm.). In the absence of daily data on restrictions in supply from the RDR the irrigation days lost have been calculated as:

No of days in period * Percentage restriction = Irrigation days lost

The estimated losses in pasture production at different periods in the irrigation season in the MHIL and ALIL/VIL scheme areas are shown in Table 7 and Table 8. Total annual irrigated pasture production in the absence of restriction is assumed to be 16,500 kilograms of dry matter per hectare (KgDM/ha).

Table 7: Pasture production losses in the MHIS area (total KgDM/ha lost)

	Early season	Dec	Jan	Feb	Late season	Total loss	% of total prod'n
Mean	618	293	285	350	933	2,479	15%
1 in 5	788	298	295	452	1,362	3,195	19%
1 in 10	935	351	419	544	1,591	3,839	23%
Worst	1,556	538	500	694	2,050	5,338	32%

Table 8: Pasture production losses in the ALIL/VIL scheme areas (total KgDM/ha lost)

	Early season	Dec	Jan	Feb	Late season	Total loss	% of total prod'n
Mean	229	24	47	133	542	975	6%
1 in 5	398	30	58	235	970	1,691	10%
1 in 10	545	83	181	327	1,199	2,335	14%
Worst	1,166	270	262	477	1,658	3,835	23%

The Harris analyses used MPI farm monitoring models to calculate the impacts of restrictions on different farm types. These data have not been published since 2012, but the Canterbury dairy farm budget for 2012/13 (MPI, 2012) was calculated at a milk solids price of $5.25, almost identical to the medium term forecast price of $5.22 (MPI, 2015). That model has formed the basis of the analysis of impacts of irrigation restrictions on dairy properties irrigated from the RDR. The assumptions employed in the analysis included:

- The impacts on dairy farm financial performance were calculated under three potential management strategies:
  - Purchased feed was used to compensate for the reduction in pasture production associated with reductions in irrigation reliability;
  - The reduction in pasture production was reflected directly in a reduction in milksolids production;
  - Reductions in irrigation reliability resulted in an increase in feed purchases and reduced milksolids production (50:50);
- The dairy production lost has been estimated using the conversion factor of 11 kg DM to produce one kilogram of milk solids (Harris et al., 2012), and the value of production lost estimated at the medium term forecast milksolids price of $5.25/kg (MPI, 2015). Since Harris et al. (2012) found that variable costs remained unchanged when income declined from $8,900 to $7,100 per hectare ($7,600 to $6,000 at $5.22/KgMS) variable costs are assumed to remain at the monitor farm level of $5,858 per hectare under all the levels restriction evaluated;
- On sheep/beef and dairy support farms the value of lost pasture production has been estimated at $0.25 per kilogram of dry matter (Evans, 2015). Costs have been assumed to increase by the value of the feed purchased
- Arable production has been valued at a 0.05 per cent reduction in yield for every day's water lost. Harris et al. (2012) reported that in their analysis only revenue changed with yield. In the current analysis the variable costs directly linked to yield have been recalculated to reflect yield reductions. A weighted average revenue per hectare of arable production has been calculated by weighting price and cost data on Canterbury arable farms (Evans, 2015)

by the average areas and yields of irrigated crops in the Ashburton District in 2012 (Statistics New Zealand, 2012). An average value of $3,989 per hectare has been used in the analysis.

- The small area of land in "other" land-uses has not been included in the analysis.

Under these assumptions, the restrictions in the reliability of irrigation supply from the RDR have been estimated to result in reductions in the potential value-added at the farm-gate of between $22 and $45 million in the average irrigation season. These losses increase with severity of restrictions imposed, and in a season in which restrictions were as severe as the worst experienced during the past 36 years it is estimated that losses would be as high as $59-$119 million. Figure 9 shows the losses in value-added at the farm-gate in the average season; the one in five season, the one in ten season, and the worst season experienced.

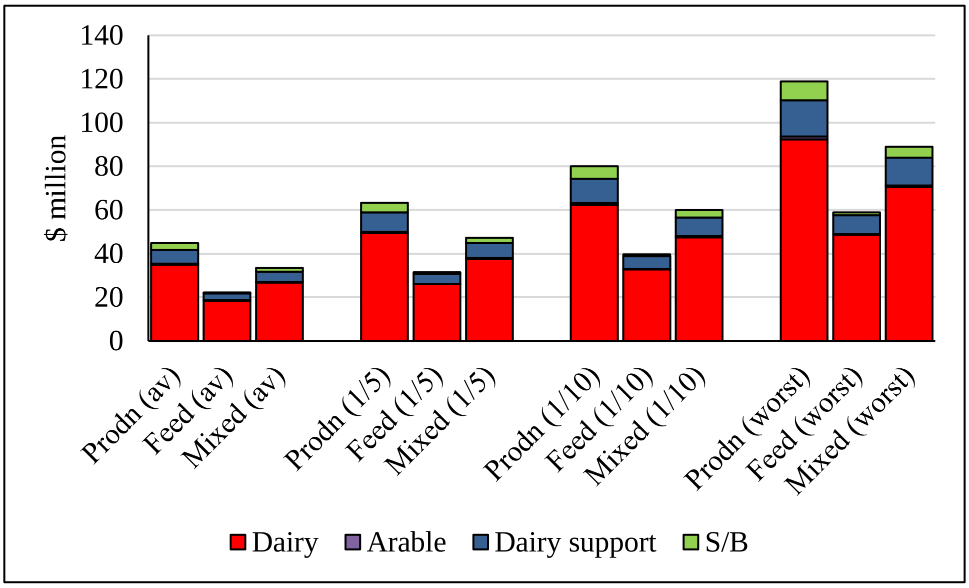


Figure 9: Reductions in the potential value-added at the farm-gate in the area irrigated from the RDR

The total value of these losses in terms of contribution to regional GDP and employment comprises the direct, indirect and induced impacts on the local economy of the farm level changes in the value of output that are the result of the irrigation restrictions. The **direct effect** is the change at the farm-gate summarised in Table 10. The **indirect effect** is the effect of changes in farm output on the output of, and employment in, firms servicing the farms in the local area, such as input suppliers and service providers. The **induced effect** is the impact of the change in household expenditure, which occurs as a result of the direct and indirect effects of changes in farm output changes, on the output and employment of other businesses in the local area. For example, reductions in the household incomes of RDR farmers may lead to a reduction in their expenditures in Ashburton shops.

Multipliers used by Saunders and Saunders (2012) have been applied to the farm-gate changes in value-added in order to calculate the indirect and induced impacts of restrictions in reliability of irrigation on farms supplied by the RDR in the average season. The total impacts of the restrictions on the Canterbury regional economy in the average season where losses comprise a combination of reduced production and addition feed costs for each farm type are shown in Table 9 be $52.3 million per annum. The total reduction in contribution to regional GDP as a result of restrictions in the reliability of irrigation supply are estimated to be between $34 million (feed costs only) per annum and $70 per annum (production losses only).

Table 9: Direct, indirect and induced impacts of restrictions in RDR irrigation reliability on regional GDP in the average season

	Direct ($M/yr)	Indirect & induced ($M/yr)	Total ($M/yr)
Dairy	26.68	12.06	38.74
Arable	0.35	0.26	0.61
Dairy support	4.67	4.68	9.35
S/B	1.78	1.79	3.57
Total	33.48	18.79	52.27

The approach used to estimate the reduction in revenue and profitability as a result of irrigation restriction did not involve the development of detailed farm financial performance models. Consequently detailed examination of the implications of these reductions on individual farm profitability was not possible. However, using the following assumptions an approximate estimate of the proportional impacts on revenue and profitability on the average dairy farm has been derived:

- The average milksolids production estimated the MPI Canterbury dairy farm model (MPI, 2012) in 2012 was 1,405 KgMS/ha (MPI, 2012);
- The ratio of milksolids income to total farm revenue at a milk price of $5.25 is estimated to be 0.89 (MPI, 2012).

If purchased feed was used to compensate for the pasture production deficit the average dairy cash farm surplus (CFS) in the average season is estimated to be 19 per cent lower than if irrigation reliability was 99 per cent. If a production loss is sustained rather, than an increase in feed purchases, the reductions in CFS are estimated to be 35 per cent lower as Figure 10 shows. In reality the loss can be expected to be somewhere between these estimates.

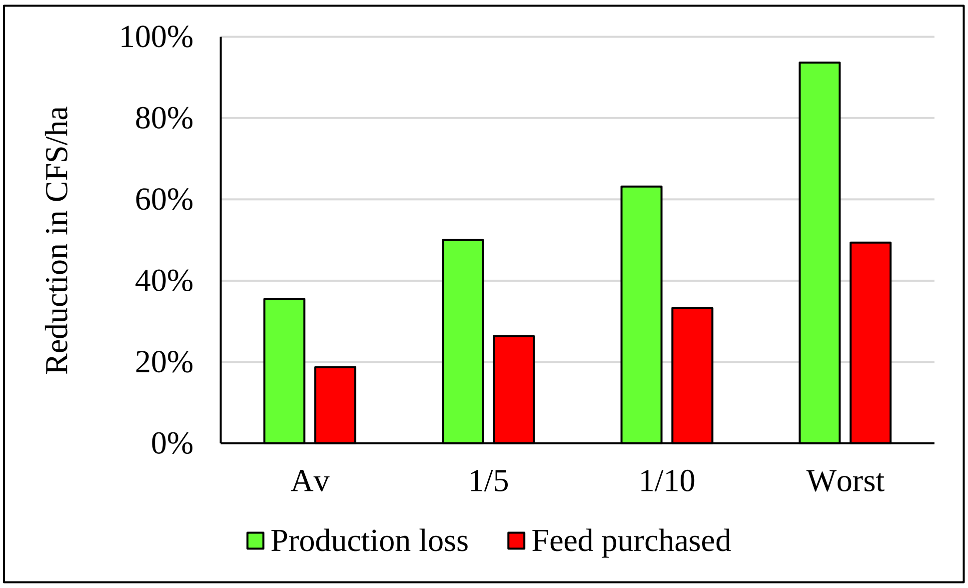


Figure 10: Percentage reduction in per hectare dairy CFS under restriction scenarios

3.1.5 The value of expansion in the area of irrigation development

The irrigation scenario that has been evaluated to estimate the impacts on the Canterbury regional economy of the proposed storage facility is that the area currently consented for irrigation development within the boundaries of the shareholding irrigation schemes (94,486 hectares) will be developed for irrigation at the current application rate. The reliability of supply to this area will be 99 per cent (PDP, 2016). It has been assumed that the landuse in newly irrigated areas would reflect the pattern of existing landuse in the RDR scheme areas.

Estimates of the economic contribution of new irrigation development have been based on the two most recent studies of the contribution of irrigation in Canterbury, which were undertaken by Saunders and Saunders (2012) and Corong et al. (2014). These studies were based on 2010/2011 and 2011/12 farm gross margin data. The differences in the values reported ($2.98 million per thousand hectares developed and $3.13 million per thousand hectares developed respectively) can be approximately accounted for by the differences in dairy prices used ($6.15 and $6.59 per kilogram of milksolids respectively).

In addition to recalculation of the value-added per thousand hectares developed to account for the medium-term milksolids price of $5.22 (see section 0) it was also necessary to account for differences in the proportional landuses in the area irrigated from the RDR, and the wider Canterbury region. Because the Corong et al, (2014) study did not report value-added by sector, the data from the Saunders and Saunders (2012) study was used to calculate the value-added estimates reported in Table 10. As the prices required to recalculate the value-added from other sectors were not reported, the value-added per thousand hectares irrigated was assumed to be the same as that reported by Saunders and Saunders (2012).

Table 10: Value-added per 000 hectares irrigated by landuse

	Dairy ($M/000 ha)	Sheep/beef ($M/000 ha)	Arable ($M/000 ha)
Saunders and Saunders (2012)	4.55	0.26	1.45
S &S (2012) price adjusted	3.46	0.26	1.45
RDR proportional land use	56.3%	29.8%	12.2%
Average contribution to value-added at the farm gate ($M 2015)			2.38

The total impacts on the Canterbury regional economy of the increased contribution of irrigation from the RDR has been calculated using the Canterbury regional multipliers derived from the AERU/CDC Economic Impact Model (Saunders et al., 2010). The impacts estimated under each scenario are shown in Table 11.

If the entire area consented for irrigation from the RDR is developed, the additional value-added at the farm-gate is estimated to be $43 million per annum, and the total contribution to regional GDP (including the direct, indirect and induced effects) to be $65 million per annum. Almost 600 jobs would be created in the region in total, of which 251 would be created on-farm.

Table 11: Contribution to regional GDP under different development scenarios

Add'n ha devt	Value-added Direct effects $M	Value-added Induced and indirect effects $M	Value-added Total effects $M	Total employment (FTES)
19,155	43.25	21.68	64.33	584

The dairy sector contributes most of the increase in GDP, both because it is the dominant landuse in the area and because the value-added per hectare from dairy production considerably exceeds the value-added generated by other landuses.

3.1.6 The value of managed aquifer recharge

Managed aquifer recharge (MAR) has been identified as having the potential to contribute to the achievement of the goals of the CWMS (PDP 2011). In addition to increasing the volumes of good quality water entering the aquifer and the streams and rivers fed by it, MAR can contribute to reduction of nitrate concentrations. Artificial aquifer recharge already occurs in the region, and within the areas irrigated by the RDR, as a result of large-scale surface supply schemes as well as leaky stockwater races. Investigations in the use of MAR as a means of enhancing Canterbury's freshwater resources are underway.

The potential economic and environmental benefits of MAR include the maintenance of groundwater levels, the enhancement of lowland stream flows and the dilute groundwater contamination from land use intensification (Jenkins, 2015). However, estimates of the magnitude of the benefits likely to arise from the implementation of MAR using stored water from the proposed Klondyke storage pond are difficult to predict in advance, because of the heterogeneity of the groundwater strata (PDP, 2011).

In addition to the potential groundwater recharge possible if MAR is implemented, leakage from the pond itself will occur, since it is not possible to install a completely leak-proof pond liner. PDP (2016a) have estimated from data provided by MWH that this leakage will be approximately 58 L/s over the area of the reservoir, which is twice the annual rainfall in the area. As a result, an increase in ground water recharge can be expected. However, the effect of this will be small in the context of the overall water balance.

3.1.7 Total annual-benefits of increased farm production as a result of the proposed development

In the average year it is estimated that the direct increase in the contribution to regional GDP by irrigated farms supplied by the RDR as a result of increases in irrigation reliability is $33.5 million, and the total (direct, indirect and induced) contribution to GDP would be $52.3 million.

If the consented area of the schemes supplied by the RDR were able to be irrigated (an additional 19,155 hectares) with average reliability of 99 per cent, as a result of the proposed development, the value of the increase in the contribution to regional GDP at the farm-gate was estimated to be $43.3 million and the total contribution $64.3 .million. The total increase in regional employment as a result of the proposed development was estimated to be 584 FTEs.

Under the assumptions employed in this analysis, the potential increase in the net value of production at the farm-gate in the average season as a result of increased reliability of irrigation supply is estimated to be approximately $77 million per annum once all development is complete. The potential total (direct, indirect and induced) contribution is estimated to be $116 million.

3.1.8 The costs of the development

Detailed cost benefit analysis of the proposed development is not part of the brief for the analysis reported. However, an approximate estimate of the potential costs of the development can be considered in conjunction with the potential benefits of increased reliability for existing irrigators and of additional irrigation development within the consented area of the schemes supplied by the RDR (Scenario 1). If water is to be supplied to irrigators outside the area significant investment in off-farm delivery infrastructure will be required, the costs of which will be dependent on the location of end-users.

Opportunity costs: In order to build the proposed storage facility, 500 hectares of land will be purchased by RDRML. All of this area will be taken out of agricultural production during the construction of the facility but approximately 213 hectares (209 hectares of farmland and four hectares of native bush) will be cleared during construction, but returned to agricultural use post-construction. Of the remainder, 245 hectares will be used by the storage facility, 41 hectares will be converted to a grassed embankment, and the lizard habitat will account for an additional hectare. The opportunity costs of removing this land from production are small. The average CFS on the typical Canterbury breeding finishing farm (which includes a small area of arable production) (MPI, 2012) for the 2012 and 2013 seasons was estimated to be $327 per hectare. Thus the net value of production lost due the construction phase is estimated to be $163,500 per annum and the on-going losses to be $93,850.

Cost of facility and associated developments: The costs of the storage pond and associated infrastructure are estimated by the engineering consultants employed by RDRML to be $3.90 per cubic meter of water, including allowances for professional fees and contingency expenditure. This is considered to be a generous estimate. Additional costs will be incurred for design of the facility, the installation of the fish screen, the canal modifications and the development of the whitewater course. In addition RDRML has commissioned a number of technical reports and will incur significant costs in obtaining the resource consents required. Table 12 summarises the approximate capital costs to be incurred by RDRML during construction of the proposed storage facility that can be estimated at this time to be $237.67 million.

Facility operational costs:

The operational costs (including required monitoring activities have not been estimated in detail but RDRML believe these likely to be of the order of $250,000 per annum.

Table 12: Costs incurred by RDRML during construction

	$ million
Storage facility (53 Mm^3 @$3.90/m3)	207.00
White water course	0.32
Canal modification	0.35
Fish screen	-
Other establishment costs	30.00
Total costs construction phase	$237.67

At an interest rate of eight per cent (Ben Curry, pers. comm.) the annual costs of supplying water to RDR farmers (comprising interest and operating costs) would be $19.26 million dollars. The costs to irrigators (and other users) per m^3 supplied will depend on the number of times the pond is filled during the year (stored water availability), and the extent to which the water available is fully utilised once the facility is operational. If the pond is filled only once during the season and all 53 Mm^3 are used the cost of supplying one cubic metre is estimated to be $0.36. If the pond is filled twice, the cost would decline to $0.18 per m^3. The average price of additional water supplied by the RDR is expected to be between $0.20 and $0.25 per m^3 (Ben Curry pers. comm.), which is comparable with the cost of supplying water from Lake Coleridge to the Barrhill Irrigation scheme of approximately $0.22 per m^3.

Without detailed farm systems modelling it is not possible to assess the affordability of water at this price on individual farms. In aggregate, irrigation of the currently consented area within the three RDR schemes with 99 per cent reliability will require 14 of the 53 Mm^3 storage (26 per cent). The annual costs of supplying this are estimated to be $5.5 million. In addition, farmers must meet the costs of new on-farm irrigation development and other costs associated with intensifying farm production in response to changes in the availability of irrigation water. The typical costs for on-farm spray irrigation in Canterbury range from $3,500 to $4,000 per hectare for farms for which development is straightforward to $5,000 to $6,000 per hectare where the development is more complex (Andrew Curtis (CEO, Irrigation New Zealand pers. comm.).

At an average cost of $4,300 per hectare the on-farm development costs are estimated to be $82.36 million. If on-farm development were to be funded by loans over 10 years at five per cent interest the annual debt servicing costs would be $547 per hectare of additional development. The average increase in net value of production associated with irrigation development has been estimated to be approximately $2,258 per hectare developed. The final margin between costs and returns will depend on the per hectare water-supply charges imposed by individual irrigation schemes. This will be affected not only by the costs of water storage but also the costs of off-farm infrastructural development required to supply new irrigators.

Chapter 4
The economic value of environmental and social impacts

RDRML has actively sought to minimise any potential environment or social costs associated with the Klondyke Storage development by commissioning a series of technical reports on the potential impacts of the construction and operation of the proposed facility on the environmental quality of the Rangitata River and the rural areas surrounding the development. Where potentially adverse impacts have been identified in these reports, plans have been formulated to eliminate or minimise these impacts. In this chapter the conclusions from the technical reports with respect to the likelihood of adverse impacts are summarised. Where possible, economic costs are estimated on the basis of data provided by the technical experts contracted to RDRML.

In addition, the development is to include the installation of a new fish screen to improve the diversion of migrating salmon smolt away from the RDR, and the development of a recreational whitewater course at the outlet of the proposed Klondyke Pond into the MHIL scheme.

4.1 Potential impacts on visual landscape and natural character

The technical assessment of the impacts of the development on the visual landscape and natural character of the area has been undertaken and reported by Brown (2016). The key findings of this assessment included:

- Most of the construction work associated with the canal modifications and the fish screen and bypass would have a limited range of effects on the amenity of residents and visitors, since most of the work would be screened from public vantage points. Once completed the proposed modifications would merge with the existing infrastructure and, over time, would become almost negligible. The broader landscape and natural character effects would be minimal since the surrounding landscape is already highly modified;
- The effects on areas closer to the water storage facility would be both limited and variable. Views of Little Mt Peel and the Tara Haoa Range will be opened up from parts of Montalto Road with the removal of existing shelter belts. At the same time, the proposed storage facility - with its ridge or hill like profile - would restrict views to the same hill country from parts of Ealing Montalto Rd further south. The facility would have little impact on views from the other side of the Rangitata River, near the Rangitata Gorge Road, and from most of Mt Peel Forest, but would be more visible from some of the more elevated tracks on Little Mt Peel and its surrounds. From this area, the storage facility's water area would be clearly apparent, but would merge with the geometric pattern of pasture, shelter belts and other man-made elements that are closely associated with the rural Canterbury. A "low", perhaps "low to moderate" impact on amenity values east of the Rangitata River, and a "moderate" effect on the views from parts of Peel Forest and Little Mount Peel as a result of site clearance and construction, are expected;
- The impacts on the natural character values of the Rangitata River system are likely to be "low" or "very low";
- Development and operation of the white water course is unlikely to generate any significant effects on the rural character of the landscape near the Ealing Montalto Road.

The Klondyke Storage proposal includes measures to protect landscape and amenity values including:

- Replacement of current shelterbelts with two shortened shelter belts, separated by a gap that would provide views from Montalto Road to the Tara Haoa Range and Mount Peel;
- Establishment of two pockets of native plantings at both ends of the embankment to break up both the linear form of the embankment and the views of the facility and associated structures;
- In order to minimise the visual impact of the emergency outfall into the Rangitata River, the concrete used will be darkened and the surface textured, native and exotic plantings will be established to screen the outfall, and large rocks will be used to break up its structural profile.

The current expectation is that four hectares of native and exotic plantings will be undertaken once the development is complete, at an approximate costs of $150,000. Overall it was concluded that the proposal is “appropriate in terms of its landscape, natural character and amenity values”.

4.2 Potential impacts on terrestrial and avian ecology

Surveys of the vegetation and terrestrial species, and observations of birds occupying the area were undertaken to inform the technical assessment of the ecological effects of the proposed development. The results of and conclusions from these are described by Sanders (2016).

4.2.1 Native vegetation

As a result of the development of the storage pond some existing native vegetation will be lost. This consists of scattered common native plants that currently grow on farmland and adjacent to the existing MHIL canal. No formal revegetation plan has been developed as yet but discussions are being held with local iwi and others to establish community preferences for the location of revegetation initiatives. Although it was originally proposed that native plantings should be established as a roadside screen, as a result of consultation with stakeholders it appears that the preferred option is that plantings will take the form of a single corridor that will have long-term protection ensured by the resource consent (see above). In addition to its landscape values, this planting may provide greater ecological benefits in terms of habitat.

4.2.2 Lizard species

As stone piles in the area adjacent to the proposed site of the storage facility had been identified as habitat for lizard species, a lizard survey was undertaken to identify the species present and the nature of the habitat. The species found include the common skink, which is categorised as “At risk: Declining” under the New Zealand Threat Classification System (NZTCS), and the Southern Alps gecko which is “Not threatened”. Development of the facility was considered to have adverse effects on lizard populations in the short-term. However, these impacts would be mitigated by the development of a one-hectare lizard sanctuary, involving the relocation of stone piles and establishment of native vegetation within a fenced area to be protected under a Lizard Management Plan (under the Wildlife Act 1953), and/or by moving lizards to nearby unaffected habitat. All work involving relocation of lizards within the site would require permits from the Department of Conservation and the establishment of habitat and relocation of lizards would be monitored.

The costs of relocating stone piles is likely to be low. Since large volumes of stone must be moved during the pond construction, strategic placement of a small proportion of the fill removed will have little effect on overall costs. One hectare of native vegetation fenced is estimated to cost approximately $30,000. The costs of monitoring and relocation have not been estimated.

4.2.3 Bird species

Bird observations indicated that the birds of the farmland adjacent to the area included only common introduced and native birds, which are typical of farmland on the Canterbury Plains, and shrubland near rivers. However, the Rangitata River is important habitat for a diversity and abundance of birds, which include several species classified as “Threatened” or “At Risk” under the NZTCS).

The conversion of more than 200 hectares of farmland into the storage facility will displace birds currently found in this area. However, additional habitat for some of these terrestrial birds will be provided by the native plantings, and the ecological consequences of the loss of farmland habitat will be minimal because of the birds that use it are common, widespread and mainly introduced.

The impacts of changes to flows in the Rangitata River will not have adverse impacts on river bird species. Flow changes will occur for short periods at much higher flows than those the birds experience before and after floods or freshes currently. A slight reduction in the risks that nests will be flooded will affect only a small number of nests.

The development is unlikely to result in environmental costs because negative effects on birdlife are not likely and there is likely to be a net benefit for native vegetation and lizards from the provision of a single contiguous area of native vegetation interspersed with rocky lizard habitat. Resource consent protection will ensure that those mitigations are maintained.

4.3 Potential impacts on transportation

An assessment of the impacts of the development on local roads and traffic volumes, during both construction and operation of the proposed storage facility has been undertaken on behalf of RDRML by TDG (2016).

The proposed development will necessitate the relocation of Shepherds Bush Road, west of Montalto Road, approximately 500 metres to the south of the existing road. In addition there will be a large increase in the volumes of traffic in the area with both heavy traffic deliveries to the site and the transport of workers during the three to five years of construction.

Consequently, measures to reduce the impacts of construction traffic for other road users will be required at several locations during the construction. A construction traffic management plan has been proposed to manage the potential adverse effects of traffic on local roads and the community, and the report also recommends that peak traffic movements are actively managed to minimise their impacts.

Measures identified in the proposed construction traffic management include:

- Addressing the sightline issue at Moorhouse Road/Mayfield Klondyke Road;
- Avoiding the use of the unsealed section of Shepherds Bush Road between Ruapuna School Road and Moorhouse Road;
- Reconfiguring priorities at the Moorhouse Road/Shepherds Bush Road intersection;
- Installation of warning signs on the Inland Scenic Route approaches to the Moorhouse Road and Ealing Montalto Road intersections;
- Undertaking a chip seal extension on Montalto Road adjacent to the construction site.

In addition a maintenance monitoring plan has also been recommended to address potential degradation of the local roads in the vicinity of the site during construction.

Provided the roading design and traffic management recommendations included in the technical assessment are followed it was concluded that during construction the road network will continue to operate with a high level of service for other road users and that the transportation-related effects will be acceptable.

The costs of the roading works to be undertaken and the monitoring of road conditions are included in the overall construction costs of the development and no breakdown of these costs is available as yet.

4.4 Potential accoustic impacts of the development

An acoustic assessment was commissioned to assess the likely noise levels during the construction and operation of the proposed storage facility, and the management activities required to ensure that construction noise does not exceed reasonable levels for residents in areas adjacent to the development. The results of the assessment have been reported by Hegley (2016).

Once the construction of the storage facility is complete, noise levels in the surrounding area will not differ from the levels currently prevailing in a typical rural environment. However, the construction phase will involve increased noise levels as the as pond construction and canal modification works proceed, and there will be increases in traffic movements, particularly heavy traffic movements in the surrounding area.

Modelling was undertaken to ensure that noise levels during construction will meet the requirement of Ashburton District Plan Rule 11.8.3, that construction noise in the district complies with New Zealand Standard 6803: 1999 Acoustics. On the basis of field measurements from other sites the upper levels of noise that will ever be experienced at the dwellings closest to the site have been estimated to be significantly lower than those permitted under the District Plan.

- The analysis found that construction noise associated with the facility itself will be “less than minor” and, for much of the time, will be at, or be lower than the existing levels of background noise in the area, and there will be no vibration effects beyond the site boundary;
- Levels of noise from construction of the white water course will be lower than those at the facility site;
- The highest levels of noise will be experienced for two to three weeks during the canal modification works but will be well within the levels specified in the Standard;
- Noise and vibration from piling will not affect neighbouring properties;
- There will be no noticeable noise from construction or operation of the fish screens.

While traffic levels will increase significantly during the construction phase it is considered that any increase in traffic noise will be well within acceptable limits. At present traffic noise associated with developments of this type is not restricted by legislation or District Plan rules. However, the expected increase in traffic noise is well within the levels established by the proposed new standard (NZS 6806:2010 Acoustics - Road-traffic Noise - New and Altered Roads). With the possible exception that a concrete pour may continue into the night, there will be no increase in vehicle traffic during the night

Consequently the noise assessment concluded that, “although noise levels will increase in the area during the construction stages as a result of the earthworks; canal work; construction; and increase in traffic, the effects of these on neighbouring houses will be less than minor”.

4.5 Potential impacts on air quality

Potential discharges to the air from construction and operation of the pond have been evaluated in the context of the requirements of the Environment Canterbury (ECan) operative Natural

Resources Regional Plan (NRRP) and the proposed Canterbury Air Regional Plan (pCARP). The rules in the pCARP have been operative since 28 February 2015. On the basis of the technical assessment undertaken by Beca (2016a), dust and smoke management plans have been prepared for RDRML (Beca Ltd, 2016b; 2016c), which employ mitigation techniques recommended by the New Zealand Ministry for the Environment, Environment Australia, the Greater London Authority and the UK Institute of Air Quality Management. These are included in the construction management plan.

Construction of the pond, canal modification, fish screen installation and construction of the white water course will involve a number of activities that have the potential to result in discharges of dust, smoke and diesel fumes into the air. An extensive list of mitigations and monitoring measures to be implemented at each stage of the construction have been proposed by RDRML to ensure that the effects of the discharges are mitigated to the extent that they will not be offensive or objectionable. The technical assessment has concluded that provided these measures are adopted the proposed development is consistent with the rules and policies enforced by the NRRP and pCARP.

This will mean that overall the impacts of discharges to air will be “no more than minor”. Specifically:

- The effects of discharges on the property closest to the development will be “no more than minor”, and that the effects on other properties will be “ less than minor”;
- Any adverse effects on vegetation resulting from dust deposition during construction of the pond are expected to be temporary and “less than minor”;
- The health of residents will be affected to a “less than minor” extent by particulate discharges from earthworks and construction vehicles and equipment;
- Adverse effects of smoke discharges from burning vegetation on amenity values and visibility are expected to be “no more than minor” provided recommended mitigation practices are employed.

Monitoring of ambient dust and weather (wind speed, wind direction, and total suspended particulate concentration on-site or in the vicinity of the site) commenced in August 2015 and will continue throughout the construction period. RDRML will incur an annual charge of $35,100 per annum (Prue Harwood Beca Ltd, pers. comm.) for this service until construction is complete.

4.6 Potential impacts on aquatic ecology and surface water quality

The impacts of the construction of the proposed Klondyke reservoir on Rangitata water quality and ecology, and on the water quality of the reservoir itself were assessed on behalf of RDRML by Ryder and Goldsmith (2016).

The assessment found that there is currently no significant indigenous habitat or fauna round the site of the proposed development. Nearby seepages at the base of the river terrace will not be directly affected and their supply of water via seepages should not diminish. Measurement of nutrient and faecal bacterial levels showed that the RDR currently has “very good” water quality, which reflects the quality of the Rangitata River in this section

The Rangitata River is protected by the WCO, Clause 11 of which sets out restrictions on any alteration of water quality in the river. With respect to the conditions set out in the WCO:

- Discharges of water into the river may not alter the **natural temperature** of the river by more than three degrees Celsius (3^o C) and may not increase the temperature to more than 20^o C. While modelling has suggested that temperature changes of 3^o C are possible, there is little opportunity for a discharge to adversely affect downstream river water temperatures.

Temperature monitoring and management of sluicing events will ensure that the Clause 11 requirement is met.

- **Faecal contamination** of the reservoir is only possible through birds congregating and their contribution to faecal bacteria is unlikely to be sufficient to significantly elevate downstream river concentrations. In addition discharges from the pond to the River are unlikely to occur over more than two days, while the limits on E coli concentration are based on the measurements from five samples over 30 days. Consequently the assessment found that this requirement will not be breached.
- The discharges to the river are not expected to cause the **pH level of the River** to fall outside the permitted range of 6 to 9 units. In addition the management of sluicing operations will be used to ensure that differences in pH between the river and reservoir water are minimised.
- Because discharges from the reservoir are intermittent, opportunities for intermittent discharges to lead to **biological growths** in the river are not foreseen. The risk of cyanobacterial cells contaminating the river will be managed by monitoring prior to discharge, and before recreational uses of outlet water including hunting.
- Reduced **dissolved oxygen** levels in the Rangitata as a result of sluicing operations are highly unlikely. When sluicing occurs the pond will first be drawn down to expose the pond floor, removing any thermal stratification and deoxygenation in the lower levels of reservoir water.

No significant risks to water quality associated with potential discharges from the reservoir have been identified. As the quality of in-flow water is generally good it is expected that outflow temperature, nutrient and faecal bacterial levels will be similar. While there is potential for the development of cyanobacterial blooms, this can be reduced by monitoring water quality and managing discharges on the basis of monitoring results. Recommendations for monitoring and management of water quality associated with the proposed development have been set out in the report on the assessment, while measures to minimise sediment exposure, run-off and sediment-laden discharges are reported by MWH (2016a).

4.7 Potential impacts on groundwater

The groundwater technical assessment (PDP, 2016a) found that, provided construction activities are carried out appropriately, the effects on groundwater quality or quantity as a result of the construction and ongoing maintenance of the proposed storage reservoir can be expected to be "no more than minor and therefore are considered acceptable". This conclusion was reached because the investigation found that:

- There are very few **groundwater bores** in the vicinity, and the nearest down-gradient domestic bore is 1,500 m away while the nearest community supply bore is 6 km away;
- The **depth to groundwater** is expected to remain at least 15m below the base of the reservoir and be much deeper in the location of the majority of construction works;
- **Run-off and run-on water** will be treated in retention reservoirs or returned to surface water or discharges to groundwater via soakpits;
- Most **refuelling** will be carried from a single site in the vicinity of a sealed storage tank above the river where the water table is deep. An impermeable membrane beneath he refuelling tank, and a perimeter bund sufficient to contain a significant spill will be constructed. Refuelling close to the river will occur via mobile min-tankers in sealed bunded areas, large enough to contain large spills. There is considered to be a very low risk of a hazardous spill adversely affecting groundwater.

- **Leakage from the pond** is expected to occur at twice the rate of the annual groundwater recharge from rainfall. This represents a very small positive impact on groundwater recharge. The reservoir could contribute more to recharge if water is used for MAR or TSA.
- The proposed **additional 10 m^3/s take** from the Rangitata River is not expected to cause a measureable lowering of groundwater levels adjacent to the river and, therefore, water levels in bores in the vicinity of the river are not expected to be affected by this additional take.

4.8 Potential impacts on hydrology

The hydrological effects of the development were assessed using a spreadsheet model to examine the impacts of increased water availability in the consented RDR supply area. The results of the modelling indicated that the hydrological impacts of the development include:

- A small reduction in residual flow in the Rangitata River downstream from the RDRML take;
- No change to median minimum, 7D MALF, lower quartile and upper quartile flows;
- Very little change to the existing frequency of floods and larger freshes;
- Because flows below 132.6 m3/s at Klondyke will not be affected by the development there will be no reduction in the wetted area, depth or velocity for much of the time. The estimated maximum reduction of 5.6 per cent, 4.1 per cent and 3.9 per cent in these parameters respectively.

The potential adverse effects on existing users, sediment transport and river morphology, river mouth behaviour, and local drainage are considered to be "less than minor". The impacts on the flow in the RDR and the supply of water to other parties taking water from the RDR of the use of 0.5 m^3/s from the RDR during construction are also expected to be "less than minor">.

4.9 Potential for a dam break

The potential impact of a dam break is often a matter for concern to residents in areas in which irrigation dams are constructed. A dam break study for the proposed Klondyke storage pond was undertaken by MWH (MWH, 2016b) for RDRML. Computer modelling was used to assess the impacts of dam breaches at two locations. The conclusion from this research was that the Klondyke storage pond should be assigned a high Potential Impact Classification (PIC). As a result the design, construction and operation standards of the facility will be required to meet the highest level specified under the New Zealand Dam Safety Guidelines (2015), and these will be incorporated into the facility design.

Provided the Dam Safety Guidelines are followed, MWH concluded that the risk to people and property "will be minimised to a very low level, which is consistent with international best practice for dam design, construction and operation".

4.10 Potential impacts of the proposed fish screen

In order to meet the conditions of the resource consent CRC011237 under which water is diverted from the RDR, RDRML installed a bio-acoustic fish screen in 2008 to prevent migrating salmon smelt from being diverted from the river into the RDR. However studies undertaken by Fish and Game New Zealand and RDRML have shown that there are problems with the efficiency of the screen's operation. Although improvements to both the fish screen and bypass have been made, trials conducted between 2008/09 and 2014/15 have found varying levels of efficiency depending on the size of fish released from the hatchery, and on the release site. Efficiency has shown to vary from less than 10 to almost 100 per (Mark Webb, Central South Island Fish and Game, unpublished letter).

The salmon fishery of the Rangitata River is regarded as one of the best in in New Zealand, and the recreational value of the river is recognised in the WCO. Kerr and Greer (2004) estimated the annual value of the Rangitata to New Zealanders holding fishing licences was of the order of fourteen to fifteen million dollars. The value of the salmon fishery alone has not been estimated,

As part of the proposed development of the storage facility, a new fish screen is to be built and trials have been undertaken on behalf of RDRML (Riley Consultants, 2016a) to determine the design of a screen that will improve the diversion of both trout and salmon species from the RDR, and the most appropriate location for the screen. The screen will be located immediately downstream of the RDR sand trap, and a fish bypass will be constructed to return fish to the main body of the river. After consultation with stakeholders it was concluded that the bypass should be constructed as an open channel, piped only where it crosses the existing sluice channel. No estimate of the construction costs of such a screen is available as yet.

4.11 Potential impacts of the proposed recreational whitewater course

Investigation of the options for the construction of a recreational whitewater course at the outlet to the MHIS has been undertaken by Riley Consultants (2016b) on behalf of RDRML. The preferred option, considered to be a safe and enjoyable facility for users with wide-range of skill levels is a “single standing wave, washing out into a slack water pool”, with potential for future expansion of the course between the outlet and the existing irrigation race. A similar facility was constructed at Lake Hawea in 2012. A construction methodology for this facility has been developed by Riley Consultants (2016b), and the expected cost of developing the course is estimated to be within the range of \$260,000 to \$370,000

No estimate of the demand, or potential social benefits of, for this facility has been undertaken as yet, but kayaking is recognised as a growing sport in New Zealand (Rankin et al, 2014). In 2013/14 it is estimated that 9.5 per cent of men and 6.9 per cent of women in New Zealand had participated in kayaking/canoeing during the previous year. It ranked as the eleventh most popular sport for men and the thirteenth most popular sport for women, and was most popular amongst men between 35 to 49 years of age. Four per cent of men were interested in increasing their involvement in kayaking (SportNZ, 2015).

4.12 Potential impacts on recreation and tourism

An assessment of the positive and negative impacts on recreational uses of the Rangitata River found that the proposal that RDRML had taken a balanced approach in developing the proposal and that “it will not result in unacceptable outcomes for recreation” (Greenaway and Associates, 2016). The assessment took account of the impacts on landscape and amenity values, freshwater, terrestrial and avian ecology, and the development of the white water course, which have described in this chapter, as well as the following impacts before reaching this conclusion:

- The Rangitata River has “outstanding value for jet boating, kayaking, salmon fishing and rafting according to the WCO. The assessment found that changes in water flow as a result of the development would not change the availability of suitable flow for trout fishing or jet boating below SH1 and that there would be increased availability of flow for kayaking, salmon fishing and rafting. There will be small reductions in the number of days available for jet boating between the Arundel Bridge and SH1, and the number of days of flows above $100m^3$/second, suitable for advanced kayakers between the RDR intake and the Arundel Bridge.

- Extending Shepherds Bush Road to the top of the river terrace gives public access to the river, which is currently permitted only by the grace of the landowner and car parking will be provided at the end of the road.

4.13 Summary

The technical assessments commissioned by RDRML have found that the potential environmental and social impacts of the proposed development are expected to be, or can be managed to be, acceptable to the wider community. Many of the mitigations required to ensure that these impacts are minimised are to be incorporated into the design of the facility, while others will be built into resource consent conditions, or other legislative requirements. Table 13 summarises the expected impacts, the strategies proposed to minimise these and, where possible the costs to be incurred by RDRML in doing so. In fact, most of the costs of compliance with proposed mitigation strategies have not yet been separately identified, and are not included in the sum of the additional development costs discussed in this Chapter ($440,000 - $550,000) plus annual costs throughout the construction period of $35,000). This figure is a significant under-estimate of the resources that will be committed by RDRML to ensure that the environmental and social costs of the proposed development are avoided, mitigated or minimised, and to provide greater protection of the Rangitata fishery and enhanced recreational opportunities for local residents and visitors

Table 13: Summary of environmental and social impacts

Impact	Scale of impact	Management strategy required	Cost
Visual landscape Natural character	• Canal modifications and fish screen construction– minimal impacts • Views and amenity values impacts from low to moderate • Natural character of River – low or very low	• Shelter belts replaced • Native plantings established • Design of emergency outfall to minimise visual impact	$150,000 Included in design and construction costs
Terrestrial and avian ecology	• Native birds – no impact • Improvements in native vegetation, and lizard habitat	• Lizard sanctuary developed • Revegetation corridor established	$30,000
Transportation	Acceptable	• Traffic management plan • Road maintenance monitoring	Unknown – included in construction costs
Noise levels	• District Plan requirements will not be exceeded by noise levels during construction • Increase in traffic noise within acceptable limits	• Noise level management strategy • Traffic management plan	Costs of modifications included in construction costs
Air quality	Less than minor (smoke “no more than minor”) provided extensive monitoring and mitigation are conducted	Smoke Management Plan Dust Management Plan Ambient dust and weather monitoring	Monitoring $35,100 per annum during construction
Aquatic ecology and surface water quality	• No significant fauna or habitat at the pond site • WCO conditions met with respect to water quality	Monitoring during operation	Included in operating costs
Groundwater	No more that minor	Construction specifications to minimise risks Consents manage the effects of activities	Included in construction costs

Hydrology	Less than minor	-	-
Dam break	Risk to people and property minimised to a very low level	PIC high. Design to incorporate requirements of Dam Safety Guidelines (2015).	Not known, incorporated in construction costs
Fish screen	Positive benefits for fish species as a result of increased diversion from the RDR		Not known
White water course	Increased recreational opportunities available.		$260,000-$370,000
Recreation and Tourism	Impacts “not unacceptable”	Balanced approach to development	_

Chapter 5
Summary and conclusions

The proposed Klondyke storage development will lead to improved reliability of irrigation for existing irrigators in the three schemes supplied from the RDR and ensure that the water required to irrigate the remainder of the area consented for irrigation development in the schemes is available. A considerable volume of water will also be available for use by other irrigators, such as Barrhill Chertsey Irrigation Ltd, and uses other than irrigation, including MAR, as well as potential economic, environmental and recreational uses that have not yet been identified.

The economic analysis of the potential contribution of the proposed development to the regional economy has been restricted to the increased reliability of irrigation to existing irrigators and the development of the remainder of the consented area since other uses. The analysis has been undertaken on the basis of secondary data from studies previously undertaken on the value of increased reliability and irrigation in development in the Canterbury Region.

Although the RDR has access to 93 per cent of its maximum allowable water take over the whole irrigation season, which is regarded as high, restrictions apply in most seasons, particularly during the period when the demand for irrigation water is highest. In addition, significant changes to the minimum flows in the Ashburton River are expected to reduce that reliability considerably in the medium term, and climate change is expected to exacerbate water restrictions throughout Canterbury in future.

The proposed development has the potential to a make a significant contribution to the local and regional economies, and will contribute directly to achievement of the targets of the CWMS. The potential value of increasing the reliability of supply to existing RDR irrigators has been estimated to be between $22 and $45 million at the farm-gate in the average season. The total (direct, indirect and induced) impact on Canterbury Regional GDP has been estimated to be between $51 and $70 million per annum. Although it has not been possible to estimate the impacts of the average irrigation restriction on profitability at the individual farm level, an estimate based on MPI farm monitoring data (MPI, 2012) suggest that in the average season CFS on the average dairy farm would be between 19 and 35 per cent higher if irrigation supply were consistently reliable.

If development of the remaining consented area within the scheme boundaries were facilitated by the development of the Klondyke storage facility an additional 19,155 hectares would be irrigated - an increase of 11.4 per cent of the area irrigated in the Ashburton District in 2012 (Statistics New Zealand 2013). In the average season it has been estimated that the additional direct contribution to regional GDP from this area would be $43 million, and the total (direct, indirect and induced) contribution has been estimated to be $64 million per annum. A total of 584 jobs would be created in the region, of which 251 would be created on farms in the Ashburton District.

The potential total (direct, indirect and induced) contribution of increased availability of water for irrigation from the RDR to irrigators within the scheme boundaries has been estimated to be between $116 million, once all development has been completed. While the impact of increased reliability for existing irrigators will be realised on completion of the storage facility, the benefits of increased irrigation development will be realised only as farm development work is completed.

While a cost benefit analysis has not be undertaken as part of this study, the total development costs of the facility have been estimated to be $238 million and the additional costs of on-farm irrigation development approximately $82 million. It is expected that the costs of water supplied from the facility will be comparable with the costs of water supply from Lake Coleridge to Barrhill Chertsey Irrigation Ltd.

The potential for adverse environmental and economic impacts to arise as a consequence of the development has been evaluated in the technical assessments commissioned by RDRML. A number of mitigations to ensure have been included in the design and construction plans for the facility and in operating plans adopted by RDRML, many of which area enforced by consent conditions to ensure that the development imposes no significant environmental or social costs on the wider community. Costs for most of the mitigations have yet to be separately identified in the total construction cost estimates. Provided the recommended mitigations are undertaken the environmental and social impacts that have been the subject of technical assessments are not expected to be significant.

Positive social and environmental impacts will be associated with the construction of a more efficient fish screen that will enhance the protection of the Rangitata River fishery, and with the proposed whitewater course will increase the recreational opportunities available in the district. In addition, water from the development will be available for MAR, which has been identified as an avenue to improving Canterbury's freshwater ecosystem health, by reducing nitrate concentrations in groundwater and lowering water temperature in spring-fed streams.

The estimated potential annual contribution to regional GDP of the proposed Klondyke storage proposal, associated with increased reliability of irrigation and increased irrigation development within the area currently consented for development from the RDR, is expected to significantly outweigh the sum of social and environmental costs and the mitigation expenses incurred in minimising these. In addition, although these have not been quantified:

- Economic benefits may be generated by other users of the stored water for additional irrigation outside the RDR schemes or for uses yet to be identified, including MAR;
- Environmental benefits will be generated by the installation of a more effective fish screen to reduce the numbers of salmon and trout entering the RDR, and may be provided by the availability of stored water for MAR, and if the irrigation application rate is increased, reduced nutrient leaching as a result of greater uptake by plants;
- Social benefits will be derived from the development of the white-water course.

The proposal has the potential contribute directly to the CWMS targets of increasing the area developed for irrigation in the region and improvement in the reliability of irrigation water supply for existing irrigators, without increasing pressure on the region's freshwater resources.

Improving the efficiency of water use is considered to be "fundamental to the CWMS" (Canterbury Water, 2009b). In addition, Section 7(b) of the Resource Management Act 1991 (RMA, 1911) states that "*all persons ... managing the use, development, and protection of natural and physical resources, shall have particular regard to ... the efficient use and development of natural and physical resources*." Improvements in the efficiency of water use can be achieved at the farm level, at the scheme level and at the catchment level. The proposed

Klondyke storage development has the potential to contribute to improvements in efficiency at all levels, including:

- Farm level:
  - Acceleration of the trend towards the use of more efficient irrigation technology by existing irrigators, in particular the change from border-dyke to spray application, because increased returns associated with increased reliability of irrigation will increase the affordability of such development;
  - Certainty of supply means that irrigators will only use the water that they need (CWMS, 2009b).
- Scheme level – Facilitation of irrigation of almost 20,000 hectares of land, already consented but not developed for irrigation, thus increasing the efficiency of the existing distribution infrastructure;
- Catchment level – the availability of storage means that a greater proportion of the water available trhoughout the year can be used for irrigation withoutcompromising environmental or other values.

However, development of the storage facility will reduce the incentive for improvements in the efficiency of the MHIS distribution infrastructure in future, since a very high level of irrigation reliability will be achievable without such improvement.

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