

# **Economic Modelling**

**A Tool to Assist Evaluation of the Canterbury Water  
Management Strategy**

**and**

**Trial Scenario 1 Assessment**

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## **Economic evaluation tool for infrastructure**

Harris Consulting have developed the economic model of the CMWS area that allows evaluation of the economic costs and benefits of infrastructure proposals. It has been tested on one scenario – Scenario 1 – which is contained in this report. It should be emphasised that this was a trial scenario to develop the tool and does not necessarily represent the programme of the Canterbury Water Management Strategy which has still to emerge over the next 12 months.

The purpose of this study was to refine the modelling tool and make it as sensitive as possible for use in policy comparisons, for example, the level of efficiencies that can be gained in irrigation systems can have a major impact both on the infrastructure required and the costs of delivering water. Assessment of potential efficiency gains will emerge from the work of zones and, where possible, will be factored into the modelling.

## **Background**

The desired outcome of the CWMS is:

*To enable present and future generations to gain the greatest social, economic, recreational and cultural benefits from our water resources within an environmentally sustainable framework.*

The CWMS commissioned the preparation of an economic assessment of the potential economic and related benefits of irrigation development in Canterbury. It is envisaged that the modelling instrument could be used to feed in different assumptions and data thereby enabling the evaluation of different development options and combinations. In so doing it can test that the presumed economic gains are real and can begin to quantify those economic gains

The first stage of the exercise has been completed and the economic assessment was tested on one scenario – “Scenario 1”. Scenario 1 was developed to test that the model could be applied across Canterbury and is a scenario that has storage infrastructure available to most parts of the region. The storage options were those for which information on costs was readily available. There is no assumption that storages used in Scenario 1 are acceptable to the Canterbury Water Management Strategy, nor that they will be implemented.

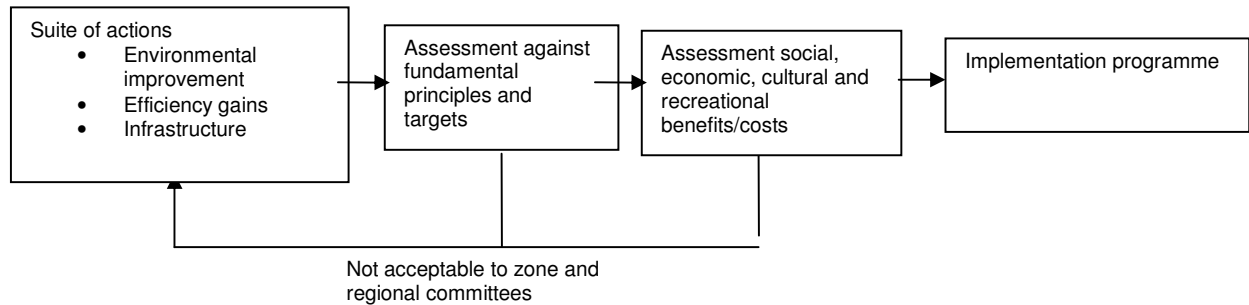
Once further scenarios are formulated, especially as the work of the Zone Water Management Committees and the Regional Committee advance, they also will be tested using the framework that has been developed.

The assumptions behind the model are clearly spelt out in the attached assessment. Where possible environmental, conservation and amenity costs have been factored into the model and explained.

## **Evaluation approach**

Evaluation of the CWMS is much wider than purely economic considerations, however. Economic criteria are just one set of evaluative criteria the CWMS intends to use. Further, irrigation development is one part of the strategy. In fact, an integrated suite of actions on environmental improvement, water infrastructure and efficiency gains are proposed.

The development of an implementation programme, which is the key role of zone and regional water management committees, will require evaluation by them of different combinations of options and strategies for action. The most appropriate mix of actions across environmental improvements, infrastructure and efficiency gains will be determined by the zone and regional committees taking all aspects into consideration. Some evaluation will occur through discussion and debate and some through the use of information, tools and models. Whatever the approach, in essence evaluation will follow a process as outlined below.



Full evaluation of any proposal will require assessment against the Fundamental Principles (contained in the November 2009 edition of the Strategy), the Targets (soon to be publicly reviewed and posted on the web site), and the assessment of the social, economic, recreational and cultural costs and benefits.

## Evaluation tools

Tools exist that can help the zone and regional committees assess some benefits and costs of some of the strategy actions. The development costs and economic benefits of infrastructure are aspects of the strategy that can be evaluated quantitatively by economic modelling. Other costs and benefits associated with infrastructure can be qualitatively described.

Work is underway to assess the ecosystems services value of Canterbury’s water resources, which will provide zone committees with some quantitative information on the value of instream environmental improvements.

Not all aspects can be quantitatively assessed but must be considered by the committees. Cultural values mapping and cultural impact assessment can be combined with State of the Takiwa tools and customary knowledge to assess the effects on cultural values.

## Canterbury Water Management Strategy February, 2010

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## Executive Summary

### Background

1. The Canterbury Water Management Strategy is the outcome from a process whereby the major stakeholders are developing a strategic vision for the management and development of Canterbury's water and land resources. The draft strategy calls for changes to the way that water is managed within Canterbury. There will be significant new emphasis on water quality and biodiversity improvements, efficiency, and water charging regimes.
2. This report outlines the development of a model that is able to report on the implications of key parts of the CWMS. The analysis focuses primarily on the water services infrastructure and associated irrigation. The focus on infrastructure does not in any way detract from the overall emphasis of the strategy on parallel development of all stakeholders' aspirations for the water bodies. The need for mitigation and remediation of water bodies are an integral part of the strategy, and in a sense the model outcomes record the gains that can be made in one sphere, and which are available to be used to facilitate wider aspirations of the community.
3. The report outlines the development of the model, and reports on the outcomes of Scenario 1, which involves large scale development of irrigable land in Canterbury at high reliability, and involves storage infrastructure at Tekapo, Coleridge, Lees Valley and Hurunui. The assumptions used in this first scenario can be readily changed, and it is anticipated that other scenarios will be tested as the CWMS is further refined. These other scenarios will vary the areas irrigated, reliability, storage and distribution facilities (and costs), timing, and efficiency gains. There is no assumption that storages used in Scenario 1 are acceptable nor that they will be implemented.

### The CWMS Economic Model

4. The CWMS economic assessment model is written in Microsoft Excel. It covers the major elements of irrigation storage, infrastructure, distribution, application and farm systems. The model allows users to specify how the different parts of the system operate, and their cost per unit area. Key elements of the model include:
  - Irrigated area, reliability and storage – can be user input or calculated from a combination of the other two
  - River flow regimes – as provided by ECan based on existing regimes, proposed NRRP and other proposed variations
  - Reliability – based on calculated relationships from Aqualinc for given irrigated areas and storage volumes
  - Storage – four storage sites were included, with no implied endorsement of their suitability or availability
  - Efficiency gains – estimated for distribution and irrigation systems
  - Returns – derived from a number of expert assessments and adjusted for reliability

- Capital costs – as estimated from a number of pre-feasibility studies for irrigation and storage schemes
- Energy use – based on estimates of irrigation use and generation changes from different storage sites
- Environmental impacts – nitrates leached estimated by Overseer for base farm models.

## Results Scenario 1

5. Changes in irrigation by area are shown in Table 1 below. The greatest increases are in Mid, Central and North Waimakariri where the combination of surface water and increased groundwater takes from recharge add a combined 195,000 ha of irrigated area.

**Table 1: Irrigated area Scenario 1 (ha)**

	Surface Water Zone		GW Zone		Total Additional Area
	Total irrigated Scenario 1 including existing irrigation and new development (ha)	Net increase from CWMS (ha)	Total irrigated Scenario 1 including existing irrigation and new development (ha)	Net increase from CWMS (ha)	
South Canterbury	130,041	17,000	39,249	0	17,000
Mid Canterbury/South Rangitata	139,348	31,610	131,359	52,863	84,472
Central	70,364	21,691	85,249	42,747	64,438
North Waimak	51,808	22,258	36,233	23,765	46,022
Waipara	1,223	343	3,387	0	343
North Canterbury	86,553	23,770	7,992	0	23,770
<b>Total</b>	<b>479,337</b>	<b>116,671</b>	<b>303,469</b>	<b>119,374</b>	<b>236,046</b>

6. Irrigation development in Canterbury overall requires a total of \$5.2 billion in investment, with the majority of capital expenditure in delivery infrastructure and farm system capital associated with changes in intensity and type of land use. A part of this expenditure, particularly in the South Canterbury (Hunter Downs) and North Canterbury (Waiau) would take place regardless of the CWMS.
7. The modelling has generated estimates of the Net Present Value (NPV) of costs and benefits associated with Scenario 1 This analysis shows that the CWMS Scenario 1 would result in:
- PV benefits of \$3.3 billion
  - PV costs of \$2.5 billion
  - Net benefit (income less costs) of NPV \$0.8 billion.
8. Some caution is required in interpreting these results because the results are dependent on the assumptions used. The results are relatively insensitive to the assumptions about efficiency gains and change in groundwater assumptions, but the discount rate and returns have a larger impact on the outcomes. If infrastructure costs were to double, (a not unrealistic assumption), returns

would need to be 20% higher than baseline in order for the outcomes to be positive. However the Scenario 1 analysis shows that, with the exception of the Opuha command area where the lost electricity generation from the Tekapo takes exceeds the increase in net returns from irrigation, further development of irrigation under the CWMS is likely to yield a net benefit under the assumptions modelled here.

9. The analysis suggests that there will be important issues to address in terms of how the costs of infrastructure are spread across areas and users. It should also be noted that the estimates here do not currently factor in any environmental restoration or mitigation of environmental impacts that are likely to be required as part of the CWMS, although these may be included in future scenarios. As such Scenario 1 will overstate the returns from the irrigation development.
10. The regional economic impacts of the scheme were estimated as:
  - An increase in regional GDP of \$0.4 billion per annum on farm and \$1.7 billion per annum throughout the regional economy (8% of the regional GDP).
  - An increase in employment of 3,000 jobs on farm and 17,000 throughout the regional economy (7% of regional employment).
  - An increase in household income of \$0.8 billion per annum throughout the regional economy (7% of regional household income).
11. The estimates of environmental impacts show that in the absence of any mitigation measures, and no decrease in nitrate losses from farms, there will be increases in nitrate leaching the order of 20 – 40% in the Mid, Central, North Waimak and Hurunui/Waiiau areas, and varying impacts on the flows in different water bodies.
12. Energy use is estimated to decrease from the current situation with the CWMS. This is a result of increase in efficiency of water use, a reduction in pumping groundwater from the upper parts of the plains, and an increase in generation from Lees Valley and Burke's Pass. However there is an offset from loss of generation in the Waitaki, which results in a net increase in energy use in the Opuha command area.

## Background

Canterbury is one of the major water users in New Zealand – 58% of all water allocated for consumptive uses and 70% of irrigated land. Many water resources in Canterbury are at or are approaching their allocation limits, and further development will require new approaches. The Canterbury Water Management Strategy is the outcome from a process whereby the major stakeholders are developing a strategic vision for the management and development of Canterbury's water and land resources.

The draft strategy calls for significant changes to the way that water is managed within Canterbury. This includes

- A set of fundamental principles that underpin the strategy
- A set of targets for water quality, irrigated land area, energy and water efficiency, biodiversity, recreational values, natural character of braided rivers, kaitiakitanga and economic outcomes
- Integrated management of water allocation and quality issues within 10 water management areas each with their own implementation programme.
- New water management structures including zone and regional water management committees and a tripartite national forum
- A water executive within ECan to manage the implementation programmes on a day to day basis.
- A biodiversity restoration programme.
- A water infrastructure and services entity to assist with the design, build, finance and operation of the larger elements of the water services infrastructure.

There will be significant new emphasis on water quality and biodiversity improvement, efficiency, and water charging regimes.

The strategy envisages the completion of an economic assessment of the potential implications of the CWMS, and this report forms a key part of that assessment. This report outlines the development of a model that is able to outline the implications of key parts of the CWMS, with an emphasis on key parts of the water services infrastructure, particularly focused on large storage and distribution schemes. The model incorporates elements of the strategy around infrastructure, efficiency, and integrated management, and compares outcomes under the CWMS with the current state of affairs in water management. It should be stressed however that while this report focuses on the water services infrastructure, this does not in any way detract from the overall emphasis of the strategy on parallel development of all stakeholders' aspirations for the water bodies. The need for mitigation and remediation of water bodies are an integral part of the strategy, and these are only partially captured in some of the expenditure recorded in the modelling. In a sense the model outcomes record the gains that can be made in one sphere, and which are available to be used to facilitate wider aspirations of the community.

This initial draft report outlines the key elements of the model, and provides draft outputs of the model for a single set of assumptions. This initial scenario that is associated with providing high reliability (99%) water based on storage at Tekapo, Coleridge, Lees Valley and Hurunui.

This first scenario is known as Scenario 1 and has been developed based on the Aqualinc Stage 4 Strategic Water Study scenario. Scenario 1 is intended to broadly demonstrate the potential scope of water management in Canterbury rather than be a definitive scenario of how water management will develop. The assumptions used in this first scenario can be readily changed, and it is anticipated that other scenarios will be tested as the CWMS is further refined, and these further scenarios will vary the areas irrigated, reliability, storage and distribution facilities (and costs), timing, and efficiency gains. There is no assumption that storages used in the scenario in this report are appropriate nor that they will be implemented.

The model and the results that it reports are one part of the overall development and assessment of the CWMS. The model reports on some economic, social and environmental outcomes:

- Irrigated area
- Capital costs
- On farm costs and benefits
- Regional economics, including output, value added and GDP
- Employment, on farm and in the regional economy
- Environmental outcomes, quantitatively in terms of nitrate losses, and qualitative in terms of water bodies
- Energy outcomes, both generation and use.

The model outcomes should be read in conjunction with other assessments that are being undertaken, such as the integrated assessment framework outlined in Annex H of the CWMS Strategic Framework. The model does not address other issues such as tourism and recreation, landscape and aesthetics, biodiversity, Maori and other values that were not able to be incorporated quantitatively. The changes in these values will need to be addressed through other means.

## **Part I – Model specification**

The CWMS economic assessment model is written in Microsoft Excel. Its major elements are irrigated areas, storage, infrastructure, distribution, application and farm systems. The model allows users to specify how the different parts of the system operate, and their cost per unit area.

### **Irrigated areas**

The model allows the user to specify either the area irrigated, the water storage available, or the reliability of supply required. The user must specify 2 out of 3 of these elements, and the model then generates estimates of the remaining element. The estimates are based on a relationship was generated between area, storage and reliability (Aqualinc Research, pers. comm.) for the three main

storage locations (Coleridge, Lees Valley and Hurunui). These relationships are shown in Annex 1: Figure 1, Figure 2<sup>1</sup>, Figure 3.

The surface water areas are aggregated according to the availability of storage locations (user specified) as shown in

Table 2. Thus for the Coleridge storage location, if Lees Valley is not available the Coleridge storage services Central and Mid rather than Mid and South when Lees Valley is available.

**Table 2: Service areas for storage locations**

Storage area that services areas	Areas Aggregation	Storage availability		
		Coleridge available	Lees Available	Hurunui Available
Coleridge	Mid + south	Yes	Yes	
Lees	Central + NW	Yes	Yes	
Coleridge	Central + mid	Yes	No	
Lees	NW + Central + mid	No	Yes	
Hurunui	Hurunui + Waipara			Yes
Lees	Waipara		Yes	No

The available area for the storage location is spread across the relevant areas in proportion to their maximum area. Thus if 10,000 ha is available from Coleridge and Lees is not available, the 10,000 ha would be spread across Central and Mid in proportion to the land available for irrigation.

The model divides each geographical zone into a further two sub-areas: an upper surface water zone and lower groundwater zone. These are defined on the basis of those parts of the zone that would ideally be irrigated from surface water, and those that would be irrigated from ground water. The thinking behind this split is that using surface water in the upper zone increases the recharge in the lower zone, and therefore the area that can be irrigated from groundwater in the lower zone.

The model uses a process of conceptual transfers of water. This involves the integration of water management rather than the physical transfer of water from one location to another. For example, if there is surplus water in one area, it can be used to reduce the take from a resource that is shared with another zone, and the other zone can then increase its take from that resource. The surplus water has been conceptually but not physically transferred. This approach requires integrated management across the region however, and probably in a real time sense if the high reliabilities assumed in this report are to be achieved.

The conceptual transfer works in the model for the upper surface water sub-areas, where the available area from a storage location exceeds the maximum for its related areas, the surplus is first conceptually transferred south, and if there is still surplus this is conceptually transferred north. All conceptual transfers occur into the upper areas. If there is still water in surplus, it is used to surface

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<sup>1</sup> Care should be taken with the regression formulas shown in Figure 1 for Lees Valley. These proved to be insufficiently accurate for the purposes of the study, and specific relationships were generated for that location to a higher accuracy.

irrigate land in the groundwater zone. This surface irrigation appears in the Upper zone accounts, but does not allow for additional GW irrigation in the lower zone from recharge.

The Waipara area is a special case in that it receives no water as of right from storage– it is modelled as if it only receives water when the maximum irrigated areas in the areas to the north or south have been filled.

The groundwater areas are filled in a slightly different way. They receive water as a result of:

- Remaining development potential
- Transfers of groundwater consents from upper areas
- Surface water recharge – a constant estimate of  $SW = GW * 1.35$  has been used to estimate the relationship between additional surface water irrigation in the upper zone, and additional groundwater availability in the lower zone. This is available in Mid, Central and North Waimak areas only. In the other areas the aquifers are more complex, and it is assumed for this study that the recharge is lost from the system for irrigation.
- Efficiency – increases in efficiency in the upper zone reduce the availability of water in the lower zone at a rate of 5/8 of the original rate of 1.35, for areas where efficiency has been increased<sup>2</sup>.

The irrigated land is divided into areas, and these are further divided into an upper and lower areas, together with the area that could be irrigations in the CWMS. The estimated areas for current irrigation in each zone are shown in Table 3 and Table 4 below. These define the current and maximum areas available for irrigation. In addition a number of adjustments are made to reflect various other factors – increase in efficiency, transfer of groundwater irrigation from the upper zone to the lower zone, and transfer of surface water from the lower zone to other parts of the system. These are shown in Table 5. Column 2 of Table 5 shows the amount of groundwater in the upper zone that could be transferred to the lower zone if replaced with surface water irrigation. Column 3 is surface water in the lower zone that could be transferred – in this case it is water in the Central area that would effectively be moved to the Mid/South Rangitata area. Columns 5 and 6 describe the area which has been assumed to have an inefficient application method (border dyke) or inefficient delivery system (canals), and Column 7 describes the increase in irrigated area than could be achieved by removing these inefficiencies.

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<sup>2</sup> Assuming that efficient irrigation operates at 80% efficiency, and inefficient irrigation at 50% efficiency.

**Table 3: Area for upper zone, surface water only**

	Upper Surface water only	
	Current	Additional water available without CWMS infrastructure
South Canterbury including Opuha command area	73,041	40,000
Mid (incl Sth Rangitata)	107,738	0
Central	48,674	0
North Waimakariri	29,550	0
Waipara (Scargill and Greta Valley, upper Waipara/Mason's Flat, Omihi and Glasnevin, Amberley/Kowai)	880	0
Hurunui, Waiau, Kaikoura	23,063	39,719
<b>Total</b>	<b>282,946</b>	<b>79,719</b>

**Table 4: Irrigated area lower zone, all sources**

Area	Lower zone, all sources	
	Current	Additional available with existing resource
South Canterbury including Opuha command area	35,783	3,465
Mid (incl Sth Rangitata)	68,472	10,025
Central	42,502	0
North Waimakariri	8,054	4,414
Waipara (Scargill and Greta Valley, upper Waipara/Mason's Flat, Omihi and Glasnevin, Amberley/Kowai)	3,303	84
Hurunui, Waiau, Kaikoura	7,992	0
<b>Total</b>	<b>17,988</b>	<b>982,282</b>

**Table 5: Adjustments to irrigated areas available within model**

	Groundwater in upper zone available for transfer to lower zone	Surface water for transfer out	Surface water transfer in	Area with inefficient irrigation application method (upper only)	Area serviced from inefficient canal system area (upper only)	Increased area from efficient application and piping of canals (upper only)
South Canterbury including Opuha command area	0					0
Mid (incl Sth Rangitata)	43,938		3,500	28,088	63,000	32,603
Central	30,180	3,500				0
North Waimakariri	8,450				21,100	2,638
Waipara (Scargill and Greta Valley, upper Waipara/Mason's Flat, Omihi and Glasnevin, Amberley/Kowai)	0			572		343
Hurunui, Waiau, Kaikoura	0			1,900	5,420	2,495
<b>Total</b>	<b>82,568</b>	<b>3,500</b>	<b>3,500</b>	<b>30,560</b>	<b>89,520</b>	<b>38,079</b>

## River Flow Regimes

The flow regimes adopted for the river systems affected by storage have been advised by ECan. These are:

- Hurunui River as per variation 8 to NRRP
- Ashley River
  - a) Minimum flows 2.5 m<sup>3</sup>/s Jan to Jul, 4.0 m<sup>3</sup>/s August- Nov, 3.0 m<sup>3</sup>/s Dec
  - b) First allocation block - 1.0 m<sup>3</sup>/s
  - c) Then when river is above 6.0 m<sup>3</sup>/s a C allocation starts that is set so that the river is not flatlined for more than 15 days.
- Waimakariri River  
As per the proposed plan change to the Waimakariri River Regional Plan.

## Reliability

The reliability estimates used in the study are based on the proportion of the demand for water can be met, and is presented as % reliability. The reliability estimates were generated by Aqualinc Research Ltd using a model that includes the water hydrologically available, the rainfall, evapotranspiration, and soil type. The reliability estimate covers the entire period of record available for the water source/s, and can be thought of as average seasonal supply/demand reliability. This differs from supply reliability, which is the proportion of time or volume that full allocation is available.

## Returns

Land uses for existing and new irrigated areas were based on a number of sources, including expert input, information from the CSWS Stage I report, the Hunter Downs, Rangitata South and Central Plains scheme proposals. The information from these sources was assessed and modified where necessary for inclusion in the analysis<sup>3</sup>. These land uses are shown in Table 6.

The returns from each land use are modelled in both the with and without situation. The proportion of land in each land use, and the net cash surplus for each land use before capital costs but after management costs are shown in Table 6. For horticultural and viticulture crops with a long lead time, the returns are averaged over a 25 year period, allowing for a 7 year development lag. The returns follow the profile of changes in land use as irrigation is developed. No phase in period to allow growth to reach full production is assumed.

Reliability impacts on returns according to a specific reduction in return per % reduction in reliability. These relationships were estimated outside the model. They assume a linear relationship between reduction in irrigation availability and reduction in output. This estimate is based on a proportion of the water required by each land use being supplied by rainfall, and the remainder by irrigation, with output attributable to rainfall and irrigation in direct proportion. Where irrigation is not available the proportion of output reduces in a linear fashion. User discretion is needed in this approach, since the impact of restrictions depends on the severity, timing and duration of cutbacks in irrigation water availability. This approach merely estimates an average over the 30 year time period, and so does not describe fully the impact of reductions in irrigation availability. These additional impacts may arise from:

- Increased costs of coping with loss of feed, particularly where this effect is widespread in a region
- Need to dry off or sell animals
- Reduction in intensity of the operation to cope with increased variability.
- Threshold points at which a particular operation is no longer viable – for example grape vines or permanent horticultural crops dying from lack of water.

Previous studies comparing the approach adopted here with a simulation modelled approach have indicated that the type of approach adopted here tends to produce greater difference between the best and worst case reliability than does a modelled approach, and is less able to represent inter year variability<sup>4</sup>. However in that reported study the most important factor in determining regional returns was the viability of land uses – it mattered more that high value land uses were viable, than did the specific level of reliability that each land use experienced.

In practice the use of storage tends to mean that the reliability is quite high most years, but in very dry years there are extended periods of cutbacks in summer and autumn. It is not clear how this would impact on farming operations, and so the approach to estimating the costs of reliability may not be appropriate, particularly at the lower levels of reliability.

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<sup>3</sup> Stu Ford, Agribusiness Group, pers.comm.

<sup>4</sup> Harris Consulting, 2005. "Regional Economic Implications of Water Allocation and Reliability". Report prepared for MAF Policy and Environment Canterbury

**Table 6: Land use type, returns, and impacts of reduced reliability**

Zone	Dryland				Irrigated			
	Dairy	Arable	Other pastoral	Grapes	Dairy	Arable	Other pastoral	Grapes
South		15%	85%		55%	10%	34%	1%
Mid		20%	80%		55%	20%	24%	1%
Central		20%	80%		55%	20%	24%	1%
North Waimak		15%	85%		55%	10%	34%	1%
Waipara		5%	95%		25%	25%	25%	25%
North Canterbury		5%	95%		45%	5%	49%	1%
Returns (\$/ha) @ 100% reliability	\$0	\$507	\$507	\$0	\$2,568	\$756	\$812	\$8,244
Output/ha			\$1,185		\$7,640	\$2,792	\$1,999	\$15,089
Cost per ha per % loss in reliability	\$0	\$0	\$0	\$0	\$22	\$26	\$7	\$332

**Table 7: Assumed reliability in the absence of CSWM**

Reliability in absence of CSWM	
South	0.99
Mid	0.96
Central	0.965
North Waimak	0.94
Waipara	0.8
North Canterbury	0.95

The model assumes that reliability for groundwater is the same as for surface water in the status quo and all CWMS scenarios.

## Capital costs

The capital costs are divided into

- On farm systems changes – calculated on a per ha basis. This addresses the costs of changing farming systems to either a more intensive irrigated system, or a new land use. These costs have been sourced from RITSO reports and recent assessments undertaken for the Hunter Downs scheme. The grape costs have been based on recent viticultural development prospectuses.
- On farm irrigation development– calculated on a per ha basis. This addresses the costs on farm for installing an irrigation system, and is unaffected by the land use. These costs are based on recent (July 2009) estimates from irrigation suppliers.
- Off farm delivery infrastructure – calculated on a per ha basis. For surface water this covers races intakes, piping and races, while for groundwater it covers wells and pumps. These estimates are based on RITSO 2007 report comparing pipes with open canals, and

groundwater development costs are based on information (August 2009) from drillers. Older figures have been updated using the Capital Goods price index.

- Storage infrastructure – calculated as total costs for storage on a volume basis. The storage infrastructure and sources of information are discussed in more detail below.

Development costs are affected by the previous land use. Where no irrigation had previously taken place, the previous land use is assumed to be dryland sheep and beef pasture. However in other cases it may have been irrigated, such as where transfers occur between groundwater and surface water. The model estimates capital costs based on whether the original land use was irrigated or not (affects on farm system and irrigation costs), and whether it is changing from groundwater to surface water (affects off farm delivery infrastructure).

The capital costs of infrastructure development include environmental mitigation costs, such as development of recreational facilities, fish screening and passage, environmental flows requirements, and other mitigations directly associated with the infrastructure. It does not include unrelated environmental mitigations, which would need to be identified and addressed separately.

**Table 8: Estimated capital costs of irrigation infrastructure**

	Surface water off farm infrastructure and operating costs			Groundwater well, pumps etc not irrigators and farm system changes			
	\$/ha	Implementation time (time for irrigation to be developed post water availability, years)	Operating costs (\$/ha/year)	\$/ha	Implementation time (time for irrigation to be developed post water availability, years)	Operating costs lower zone (\$/ha/year)	Operating costs upper zone (\$/ha/year)
South Canterbury	\$4,458	2	28	\$600	1	21	41
Mid Canterbury/South Rangitata	\$4,458	2	28	\$600	1	21	41
Central	\$3,674	2	28	\$600	1	21	41
North Waimak	\$3,674	2	28	\$600	1	21	41
Waipara	\$2,206	2	28	\$600	1	21	41
North Canterbury	\$2,206	2	28	\$600	1	21	41

**Table 9: Estimated costs of on farm irrigation and farm system changes (\$/ha)**

Item	Dairy	Arable	Other pastoral	Lifestyle /Grapes/ horticulture
On farm system change capital costs	\$9098	\$300	\$2200	\$32500
On farm surface water irrigation development costs	\$4200	\$5000	\$2800	\$2300
On farm groundwater irrigation development costs	\$3700	\$4500	\$2300	\$2800

## Energy Use

The model estimates energy used in irrigation under the following assumptions:

- All new surface water is piped under pressure.
- A proportion (see
- 
- Table 10) of surface water is pumped for spray irrigation in the non efficient situation. In the efficient situation this pumping cost is replaced by delivery under pressure.
- In efficient scenario all the upper zone is piped including existing schemes, and no electricity is used (apart from groundwater if transfer does not occur).
- Pumping charges for groundwater are estimated according to location (which primarily affects depth) and whether efficiency measures have been implemented (see

Table 11).

- Electricity costs are estimated at wholesale price series<sup>5</sup> plus a retail margin of 2.5c/kWh<sup>6</sup>, and an additional 5.2c/kWh for lines charge<sup>7</sup>.
- Energy is generated from the Lees Valley dam according to the height of the dam based on MWH estimates of annual generation (Table 12). This energy is valued at the MED reference price series for wholesale electricity.
- No changes in generation are assumed at Coleridge at this stage. There are price changes that result from release of water at sub-optimal times. At a later stage a reconfigured Coleridge generation arrangement can be included should this be deemed to be appropriate.

**Table 10: Proportion of upper zone surface water that is pump sprayed rather than flood irrigated**

<b>Proportion of upper zone surface pump sprayed</b>	
South	30%
Mid	56%
Central	30%
North Waimak	80%
Waipara	80%
North Canterbury	64%

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<sup>5</sup> MED reference price series 2009

<sup>6</sup> [http://www.med.govt.nz/templates/MultipageDocumentPage\\_7257.aspx#P97\\_10428](http://www.med.govt.nz/templates/MultipageDocumentPage_7257.aspx#P97_10428)

<sup>7</sup> Electricity Ashburton 100KVA supply

**Table 11: Energy use for pumping**

Energy	Current levels of efficiency			Efficient		
	kW/ha upper groundwater	kW/ha lower groundwater	kW/ha Surface spray	kW/ha upper groundwater	kW/ha lower groundwater	kW/ha Surface spray
South	1843	2496	922	1152	1997	691
Mid	1843	2496	922	1037	1997	691
Central	1498	3994	1075	1267	2496	845
North Waimak	1498	3245	998	1152	2496	922
Waipara	1728	3744	1152	1267	2746	845
North Canterbury	1613	3494	1075	1152	2496	768

**Table 12: Energy generation from Lees Valley dam**

Item	Energy change (kW/annum)
Lees Valley High Dam	+180,000,000
Lees Valley Low Dam	+50,000,000
Tekapo take	-154,000,000
Hunter Downs extension pumping	To come

## Storage

Five storage locations were considered – Hurunui (South Branch dam), Lees Valley, Coleridge, Tekapo, and on plains. Their inclusion in this report should not be considered as an endorsement of any specific storage site or infrastructural approach, and it is noted that any or all of these may ultimately prove unacceptable for a variety of reasons.

The costs of each storage option were sourced from pre-feasibility studies by engineering firms. It is likely that these costs will have significant error margins, but are sufficient for the purposes of this study. The costs for Coleridge are as supplied by Trust power to compensate for change in electricity generation profile. No change to infrastructure associated with Coleridge is assumed in Scenario 1.

The costs of storage are spread over the supply area. For Lees Valley and Coleridge the combined costs have been spread over the Mid, Central and North Waimak areas, since it is anticipated that the water supply to these areas will be managed strategically for the benefit of all irrigators. Similarly the costs are spread over both existing and new irrigation. The manner of spreading the costs affects the relative share of the costs by zone but not the total cost.

**Table 13: Options used and cost/delay assumptions for storage options**

Item	Option	Delay until water is available	Time until construction commences	Time to build storage infrastructure	Cost/m <sup>3</sup>	Total Cost
Coleridge	Standard	3	2	1	1	\$62,500,000
Lees	Low	10	7	3	2	\$360,000,000
	High	10	5	5	3	\$409,221,517
Hurunui	Low	10	5	5	2	\$809,298,420
	High	5	3	2	1	\$51,675,647
On Plains	Waipara	2	1	1	1	\$11,410,000 <sup>8</sup>

Fill times will vary in dry periods according to the environmental flows, and the case of the larger dams may take several years. However we have assumed that this can be managed so that irrigators are still able to draw down during the period when the dam is filling, and there are no cost implications from the fill time.

The Opuha command area is also treated slightly differently, with storage water received from the Waitaki catchment. There are two options for achieving this – either directly from Tekapo, where the costs for storage are equal to the loss of power through the Waitaki hydro system, or from an extension of the Hunter Downs scheme, where the costs for water are the pumping costs for getting it into the catchment. The costs of lost hydro generation were estimated from Meridian Energy indications of losses, which were slightly less than the energy losses estimated in the SKM report for the Waitaki Water Allocation Board in 2004. Similarly Meridian estimates of the value of energy generated from a station at Burke’s Pass were included, and the costs for pumping into the Opuha command area obtained from the same source (Brian Ellwood, pers.comm.). Scenario 1 represents only the option of taking water over Burke’s Pass, and does not include the proposal to extend Hunter Downs into the Opuha command area.

## Environmental impacts

The environmental impacts presented in this study relate only to the impacts associated with new infrastructure and irrigation that arises as a result of the CWMS. Thus existing impacts, and those impacts that will occur as a result of increased irrigation that is going to happen regardless of the CWMS, are not included in the results. It should also be noted that other parts of the CWMS such as the fundamental principles relating to impacts on the environment and targets for values such as biodiversity, are not assessed directly. The capital costs associated with infrastructure do include costs for environmental mitigations directly associated with the infrastructure development, such as recreational facilities, fish screening and enhancement of environmental flows. However other mitigations not directly associated with the infrastructure have not been included in the report. In that sense it is probably useful to regard the environmental impacts described in this modelling as those which need to be managed or mitigated in the course of the irrigation infrastructure development.

<sup>8</sup> Based on 1.63 Mm<sup>3</sup> estimated by ECan to meet all requirements (100% reliability) on page 91 of the Draft Waipara River and Tributaries Environmental Flow Regimes, Report R09/3, February 2009.

Environmental impacts are largely derived outside the model, apart from nitrate losses from farmland. These are estimated using standard values for each land type from Overseer using the basic model runs. These estimates are shown in Table 14 below. Work is ongoing to develop more refined estimates for Canterbury and these will be included as they come to hand.

It should be noted that the losses may not equate to environmental impacts, since there is attenuation and other processes that occur between the loss to groundwater and the experience of an environmental impact. Nor does it address the strong emphasis in the CWMS on greater incentives for improved land use practices, nor the proposal that the release of any water from storage is contingent on water users implementing land-use practices that are in line with water quality outcomes. These issues are not able to be addressed in the modelling undertaken for this analysis, and as noted above the impacts described here can more appropriately be thought of as describing the extent of mitigation required in order for the CWMS to proceed.

**Table 14: Estimates of nitrate losses by land type (kgN/ha/year) from Overseer runs**

Land use	Dryland nitrate losses (kgN/ha/year)	Irrigated nitrate losses (kgN/ha/year)
Dairy		33
Arable	36	36
Sheep and Beef	5	11
Grapes		4

## Tourism and Recreation Impacts

The impacts of the irrigation developments on tourism and recreation in the Canterbury area have not been addressed in this model. There are a number of valuation technologies that can potentially provide a non-market valuation for the tourism and recreational values of water resources. The most widely used include various forms of contingent valuation based on surveys of willingness to pay and choice modelling, and hedonic methods such as travel cost methods which measure the actual spend of people involved in the activities. There have been a number of studies undertaken of recreational values of rivers in Canterbury, which have the most recent of these is a study by Kerr (2004)<sup>9</sup> of the recreational values associated with the lower Waitaki river. This study estimated an average value of \$36 per angler-day for freshwater sport fishing and \$21 per recreator-day for other activities, with a total recreational value for the lower Waitaki river in the order of \$2 million. As noted by Sharpe and Kerr (2005)<sup>10</sup>, this represents the total value of the recreation on the river, not the impact that changes from specific developments might cause, and is better regarded as a measure of the recreational values at risk from development.

Despite the availability of such information, it has not been possible to convert this into an estimate of the impact on recreation and tourism in Canterbury, because we have no information on:

- The nature of any impacts and their scale for different water bodies

<sup>9</sup> Kerr, GN 2004. *Lower Waitaki River Recreation Use Values*. Report to Anderson Lloyd Caudwell. Lincoln University. Cited in Sharp and Kerr 2005.

<sup>10</sup> Sharp, B and Kerr, G.N., 2005. "Option and Existence Values for the Waitaki Catchment". Report prepared for the Ministry for the Environment, Wellington.

- The size of the tourism and recreation industry associated with water bodies in Canterbury
- How any impacts, and any associated mitigations and enhancements might affect the tourism and recreational values.

For these reasons the impact on tourism and recreation will have to be assessed through means other than this model.

## PART II - Scenario 1 results

Scenario 1 was analysed using the CWMS economic model. The key assumptions for Scenario 1 are:

- Storage is available at Coleridge, Lees Valley (Low dam), Hurunui (97Mm<sup>3</sup>), and Tekapo.
- Water is supplied to the Opuha command area from Lake Tekapo.
- Reliability is set at a high level (99% seasonal availability<sup>11</sup>), and area irrigated is adjusted to achieve this level of reliability
- Transfer is enabled and distribution and irrigation efficiency gains are achieved.
- River operating rules are as advised by ECan. These differ slightly from the rules used by Aqualinc in its modelling for the earlier stages of the Canterbury Strategic Water Study, and thus the areas and/or reliabilities will differ slightly from those identified as feasible in the reporting on that study.
- The comparative scenario that describes the situation without the CWMS does not allow for efficiency gains or on farm storage. It does however allow for continued development of irrigable areas that can be reliably supplied without storage or with planned infrastructure such as Hunter Downs and Waiau command areas.

The results for Scenario 1 are discussed below.

### Areas irrigated

Table 15: Irrigated areas Upper Zone in CWMS Scenario 1

Area	Existing (incl GW in upper zone)	Water transferred in	Water transferred out (GW to lower zone)	Increased area from efficiency gains	Additional new area	Total
South Canterbury	73,041	-	-	-	57,000	130,041
Mid	107,738	3,500	(43,938)	32,603	39,445	139,348
Central	48,674	-	(30,180)	-	51,870	70,364
Nth Waimak	29,550	-	(8,450)	2,638	28,070	51,808
Waipara	880	-	-	343	-	1,223
Nth Canterbury	23,063	-	-	2,495	60,995	86,553
<b>Total</b>	<b>282,946</b>	<b>3,500</b>	<b>-82,568</b>	<b>38,079</b>	<b>237,380</b>	<b>479,337</b>

<sup>11</sup> Describes the proportion of the demand for water that can be met by the irrigation scheme, averaged on a seasonal basis for the period of record.

**Table 16: Irrigated areas Lower Zone CWMS Scenario 1**

<b>Area</b>	<b>Existing</b>	<b>Transfer in</b>	<b>Transfer out</b>	<b>Additional area from SW recharge</b>	<b>Reduced area from efficiency gains in upper zone</b>	<b>Available from existing resource</b>	<b>Total Groundwater</b>
South Canterbury	35,783	-	-	-	-	3,465	39,249
Mid	68,472	43,938	-	23,414	(14,490)	10,025	131,359
Central	42,502	30,180	(3,500)	16,067	-	-	85,249
Nth Waimak	8,054	8,450	-	16,487	(1,172)	4,414	36,233
Waipara	3,303	-	-	-	-	84	3,387
Nth Canterbury	7,992	-	-	-	-	-	7,992
<b>Total</b>	<b>166,106</b>	<b>82,568</b>	<b>(3,500)</b>	<b>55,969</b>	<b>(15,662)</b>	<b>17,988</b>	<b>303,469</b>

**Table 17: Reconciliation of irrigated areas CWMS Scenario 1**

	Surface Water Zone			GW Zone		
	Irrigated area			Irrigated area		
	With CWMS Scenario 1	Without CWMS	Net	With CWMS Scenario 1	Without CWMS	Net
South Canterbury	130,041	113,041	17,000	39,249	39,249	0
Mid Canterbury/South Rangitata	139,348	107,738	31,610	131,359	78,497	52,863
Central	70,364	48,674	21,691	85,249	42,502	42,747
North Waimak	51,808	29,550	22,258	36,233	12,468	23,765
Waipara	1,223	880	343	3,387	3,387	0
North Canterbury	86,553	62,782	23,770	7,992	7,992	0
<b>Total</b>	<b>479,337</b>	<b>362,665</b>	<b>116,671</b>	<b>303,469</b>	<b>184,094</b>	<b>119,374</b>
	Dryland Area			Dryland Area		
South Canterbury	0	17,000	-17,000	10,751	10,751	0
Mid Canterbury/South Rangitata	0	31,610	-31,610	18,641	71,503	-52,863
Central	0	21,691	-21,691	22,351	65,098	-42,747
North Waimak	0	22,258	-22,258	63,767	87,532	-23,765
Waipara	0	343	-343	6,613	6,613	0
North Canterbury	0	23,770	-23,770	2,008	2,008	0
<b>Total</b>	<b>0</b>	<b>116,671</b>	<b>-116,671</b>	<b>124,131</b>	<b>243,506</b>	<b>-119,374</b>

## Capital Costs

The capital costs of the scheme are shown below in Table 18, which indicates that the irrigation development overall requires a total of \$5.2 billion in investment. The table shows that the majority of capital expenditure will occur in delivery infrastructure and farm system capital. Note that a part of this expenditure, particularly in the South Canterbury and North Canterbury would take place regardless of the CWMS from development in Hunter Downs and the Waiau.

**Table 18: Capital costs by zone for CWMS Scenario 1 (\$ million)**

	<u>Surface Water</u>				<u>Groundwater</u>		
	<u>On farm system capital (\$m)</u>	<u>On farm irrigation capital (\$m)</u>	<u>Off farm delivery infrastructure (\$m)</u>	<u>Off farm Storage (\$m)</u>	<u>On farm capital (\$m)</u>	<u>Off farm pumps etc (\$m)</u>	<u>Total (\$m)</u>
South Canterbury	\$348	\$216	\$254	\$0	\$33	\$2	\$853
Mid Canterbury/South Rangitata	\$187	\$239	\$472	\$251	\$593	\$38	\$1,781
Central	\$128	\$87	\$191	\$127	\$403	\$26	\$962
North Waimak	\$136	\$84	\$181	\$93	\$265	\$17	\$776
Waipara	\$4	\$3	\$0	\$11	\$1	\$0	\$20
North Canterbury	\$350	\$231	\$147	\$45	\$0	\$0	\$773
<b>Total</b>	<b>\$1,153</b>	<b>\$860</b>	<b>\$1,244</b>	<b>\$528</b>	<b>\$1,295</b>	<b>\$82</b>	<b>\$5,164</b>

## On farm costs and benefits

The modelling has generated estimates of the Net Present Value (NPV) of costs and benefits associated with Scenario 1 using discounted cashflow (DCF) analysis. This analysis sums the costs and benefits at different times in the future, and discounts them back to the current day at a discount rate of 8% (which is the current Treasury guideline for government projects). The results of this analysis are shown in and in Annex 2. The DCF analysis shows that the CWMS Scenario 1 would result in:

- PV benefits of \$3.3 billion
- PV costs of \$2.5 billion
- net benefit (income less costs) of NPV \$0.8 billion.

Some caution is required in interpreting these results because the results are sensitive to capital costs and to returns, particularly dairy returns. However they suggest that with the exception of the Opuha command area, where the lost electricity generation exceeds the increase in net returns from irrigation, further development of irrigation under the CWMS will yield a net benefit under the assumptions modelled here. The negative return for Mid Canterbury surface water is affected by the inclusion of storage infrastructure costs from Lees Valley and Coleridge across all surface irrigation

land there, of which a considerable part is existing irrigation. This does suggest that there will be issues to address in terms of how the costs of infrastructure are spread across areas and users.

It should also be noted that the estimates here do not factor in any environmental restoration beyond that which has been included in the infrastructure development costings, nor mitigation of environmental impacts that are likely to be required as part of the CWMS. As such they will overstate the returns from the irrigation development.

The sensitivity of this net outcome to changes in various parameters was tested using sensitivity analysis. This testing is summarised below in

Table 19 and

Table 20.

**Table 19: Impact on Total NPV from changing different parameter assumptions (\$million)**

<b>Parameter tested</b>	<b>Net outcome (\$ million NPV, 8% except where changed)</b>
Efficiency enabled	\$796
No efficiency gains	\$650
Additional groundwater 74% of surface water	\$796
Additional groundwater 50% of surface water	\$740
Additional groundwater 35% of surface water	\$705
Discount rate 5%	\$2,710
Discount rate 8%	\$796
Discount rate 10%	\$122

**Table 20: Impact on Total NPV from changing returns and infrastructure costs (\$million discount rate 8%)**

<b>Parameters varied</b>		<b>Returns (proportion of baseline)</b>		
		<b>80%</b>	<b>100%</b>	<b>120%</b>
<b>Infrastructure cost (proportion of baseline)</b>	<b>80%</b>	\$433	\$1,011	\$1,573
	<b>100%</b>	\$218	\$796	\$1,357
	<b>200%</b>	-\$859	-\$281	\$281

Table 19 shows that the results are relatively insensitive to the assumptions about efficiency gains, and change in groundwater assumptions. This is likely to be because there are not huge net gains from increasing efficiency due to the capital costs required to achieve that efficiency, and because the areas of groundwater are not greatly altered by the recharge assumptions. However the discount rate has a major impact on the outcomes, although the result is positive even at a 10% discount rate.

Table 20 shows that at baseline infrastructure costs the outcome remains positive even at 80% of the estimated returns. Infrastructure costs have a more significant impact, and if costs were to double, (a not unrealistic assumption), returns would need to be 20% higher than baseline in order for the outcomes to be positive.

Table 21: Costs and benefits for CWMS Scenario 1 (\$ million NPV, discount rate 8%)

	Surface Water Zone			GW Zone			Total Net
	With CWMS	Without CWMS	Net	With CWMS	Without CWMS	Net	
<b>Net Income</b>							
Opuha command area	\$2,627	\$2,545	\$82	\$1,008	\$1,008	\$0	\$82
Mid Canterbury/South Rangitata	\$3,164	\$2,637	\$527	\$3,178	\$2,340	\$839	\$1,366
Central	\$1,487	\$1,252	\$236	\$2,129	\$1,451	\$678	\$914
North Waimak	\$1,011	\$792	\$218	\$1,259	\$880	\$379	\$597
Waipara	\$46	\$14	\$32	\$178	\$178	\$0	\$32
Hurunui	\$1,497	\$1,209	\$287	\$187	\$187	\$0	\$287
<b>Total</b>	<b>\$9,832</b>	<b>\$8,449</b>	<b>\$1,383</b>	<b>\$7,939</b>	<b>\$6,043</b>	<b>\$1,896</b>	<b>\$3,279</b>
<b>Net Costs</b>							
Opuha command area	\$608	\$461	\$147	\$163	\$207	-\$44	\$102
Mid Canterbury/South Rangitata	\$1,043	\$422	\$622	\$965	\$445	\$519	\$1,141
Central	\$444	\$328	\$116	\$632	\$154	\$478	\$594
North Waimak	\$311	\$129	\$182	\$348	\$89	\$259	\$441
Waipara	\$18	\$2	\$16	\$12	\$15	-\$3	\$13
Hurunui	\$547	\$350	\$197	\$26	\$31	-\$5	\$192
<b>Total</b>	<b>\$2,971</b>	<b>\$1,692</b>	<b>\$1,279</b>	<b>\$2,145</b>	<b>\$942</b>	<b>\$1,204</b>	<b>\$2,483</b>
<b>Returns - Costs</b>							
Opuha command area	\$2,019	\$2,084	-\$64	\$845	\$801	\$44	-\$20
Mid Canterbury/South Rangitata	\$2,120	\$2,215	-\$95	\$2,214	\$1,895	\$319	\$225
Central	\$1,044	\$924	\$120	\$1,497	\$1,297	\$200	\$320
North Waimak	\$700	\$664	\$36	\$911	\$791	\$120	\$156
Waipara	\$28	\$12	\$16	\$166	\$163	\$3	\$19
Hurunui	\$950	\$859	\$90	\$161	\$156	\$5	\$96
<b>Total</b>	<b>\$6,861</b>	<b>\$6,758</b>	<b>\$104</b>	<b>\$5,793</b>	<b>\$5,102</b>	<b>\$692</b>	<b>\$796</b>

## Regional outcomes

The regional outcomes report the annual change on farm and in the regional economy as a result of the increase in irrigation. The regional annual outcomes are divided into those produced on farm, and the total impacts which are those that occur throughout the community as a result of increase in the on farm production. The impacts are given as:

**Output** - Output is the value of sales by a business. In the case of wholesale and retail trade, it is the total value of turnover .

**Value-Added** - Value-added includes household income (wages and salaries and self-employed income), and returns to capital (including interest, depreciation and profits). It also includes all direct and indirect taxes.

**Employment** -Employment is work done by employees and self-employed persons, and is measured in Full-Time-Equivalent jobs (FTEs). Where work is seasonal, the conversion to FTEs is based on 12 months' work per year. So a seasonal worker working full time for six months per year is 0.5 FTEs, and a part time seasonal worker working ten hours per week for six months is 0.125 FTEs.

**Household Income** - Household income is the gross income of households. It includes the income of self-employed persons. There is sometimes considerable uncertainty as to the proportion of business income which goes to households and this is particularly the case for farms, where tax accounts are more likely to show various forms of income and drawings which are tax effective as opposed to a realistic assessment of the actual flows of funds during the year.

The estimated economic impact for the CWMS Scenario 1 is shown in Table 22 below. They show.

- An increase in regional GDP of \$0.4 billion per annum on farm and \$1.7 billion per annum throughout the regional economy.
- An increase in employment of 3,000 jobs on farm and 17,000 throughout the regional economy.
- An increase in household income of \$0.8 billion per annum throughout the regional economy.

For comparison the total economy of Canterbury is estimated at:

- Regional GDP of \$19.9 billion
- Total regional household income of \$11.8 billion
- Regional employment of 238,000 FTEs

Table 22: Regional outcomes for CWMS Scenario 1 (\$million)

	Direct on farm			Household income	Total			
	Output	Value Added	Employment		Output	Value Added	Employment	Household income
<b>Irrigated</b>								
Opuha Command area	\$90	\$38	300	\$14	\$456	\$165	1,800	\$83
Mid Canterbury/ South Rangitata	\$448	\$188	1,600	\$68	\$2,220	\$800	8,800	\$405
Central	\$343	\$144	1,200	\$52	\$1,697	\$612	6,700	\$309
North Waimak	\$238	\$102	900	\$37	\$1,206	\$434	4,800	\$220
Waipara	\$2	\$1	-	\$0	\$8	\$3	-	\$2
Hurunui	\$110	\$48	400	\$17	\$560	\$202	2,300	\$104
<b>Total</b>	<b>\$1,231</b>	<b>\$521</b>	<b>4,500</b>	<b>\$188</b>	<b>\$6,147</b>	<b>\$2,216</b>	<b>24,400</b>	<b>\$1,123</b>
<b>Dryland</b>								
Opuha Command area	-\$20	-\$10	(100)	-\$4	-\$109	-\$40	(500)	-\$25
Mid Canterbury/ South Rangitata	-\$100	-\$50	(400)	-\$20	-\$541	-\$198	(2,500)	-\$125
Central	-\$76	-\$38	(300)	-\$15	-\$413	-\$151	(1,900)	-\$95
North Waimak	-\$55	-\$27	(200)	-\$11	-\$295	-\$108	(1,400)	-\$68
Waipara	\$0	\$0	-	\$0	-\$2	-\$1	-	-\$1
Hurunui	-\$28	-\$14	(100)	-\$6	-\$152	-\$56	(700)	-\$35
<b>Total</b>	<b>-\$280</b>	<b>-\$139</b>	<b>(1,200)</b>	<b>-\$55</b>	<b>-\$1,511</b>	<b>-\$554</b>	<b>(7,100)</b>	<b>-\$349</b>
<b>Net</b>								
Opuha Command area	\$70	\$28	200	\$10	\$347	\$125	1,300	\$58
Mid Canterbury/ South Rangitata	\$348	\$138	1,200	\$49	\$1,679	\$602	6,300	\$280
Central	\$266	\$106	900	\$37	\$1,285	\$461	4,800	\$214
North Waimak	\$183	\$75	600	\$26	\$911	\$326	3,400	\$152
Waipara	\$2	\$1	-	\$0	\$6	\$2	-	\$1
Hurunui	\$82	\$34	300	\$11	\$408	\$146	1,500	\$69
<b>Total</b>	<b>\$951</b>	<b>\$382</b>	<b>3,300</b>	<b>\$133</b>	<b>\$4,635</b>	<b>\$1,662</b>	<b>17,300</b>	<b>\$774</b>

## Environmental Outcomes

The environmental outcomes are based on a combination of qualitative and quantitative assessments of the likely changes in parts of the region as a result of the development under the CWMS.

Quantitative modelling of water quantity changes has been undertaken for the fully irrigated scenario in Mid and Central areas in the CSWS stage 4 report, but for the other areas the assessments are largely qualitative based on the likely change in relative water use for each zone.

The water quality effects described are limited to discharges of nitrates and do not describe subsequent effect on environmental, recreational, cultural and drinking water values. They are also before mitigation, and since the CWMS includes a requirement for strict environmental outcomes, it can be said that these results give an indication of the size of the mitigation required rather than the actual environmental impacts. They should be seen with some caution, and are of lower reliability than the modelling undertaken by Bidwell for the CWMS Strategic Framework report (Annex C). They do however broadly align with the indications in that report that with full irrigation of available land in Canterbury there would need to be a 20% - 40% reduction in nitrate leaching to result in no increase and/or improvement of the N concentrations in aquifers.

For those areas where there is an increase in surface water irrigation but also an increase in efficiency for existing schemes and an increase in groundwater abstraction, the likely changes are more difficult to assess. The qualitative assessment should therefore be used with some caution. The assessments for Scenario 1 are shown in Table 23.

## Energy outcomes

The change in energy use was estimated from the use under existing scenario, and then estimating the energy use after taking into account further development and efficiency gains. Energy use is estimated to decrease from the current situation with the CWMS. This is a result of increase in efficiency of water use, a reduction in pumping groundwater from the upper parts of the plains, and an increase in generation from Lees Valley and Burke's Pass. However there is an offset from loss of generation in the Waitaki, which results in a net increase in energy use in the Opuha command area.

The estimated changes are shown in Table 24.

**Table 23: Estimated changes to environmental outcomes under Scenario 1 relative to Status quo**

<b>Zone</b>	<b>Nitrate losses</b>	<b>Lowland stream flows</b>	<b>Foothill river flows</b>	<b>Alpine river flows</b>	<b>Aquifer flows/levels</b>
Opuha command area	Small increase (+6%)	Improved flows	Improved flows	No change	Increase
Mid Canterbury	Significant increase (+22%)	Small decrease from improved efficiency	Improved flows from reduced abstraction	Small decrease from increased abstraction	Some decrease from improved efficiency
Central	Significant increase (+31%)	Some improvement. Some potential for reduced flows for streams originating near coast	Improved flows from reduced abstraction.	Small decrease	Some decrease from improved efficiency
Christchurch streams and aquifers		No change	Improved flows	Small decrease	No change
Lake Ellesmere	Significant increase (+37% for lower zone)	Small increase/ small decrease where originating near coast	Improved flows	Small decrease	Some decrease from improved efficiency
North Waimakariri	Significant increase (+34%)	Small decrease/no change	Change to Ashley – improved but dammed	Small decrease	Some decrease from improved efficiency
Waipara	Small increase (+4%)	No change	No change	No change	No change
Hurunui command area	Significant increase (+21%)	Small increase from increased irrigation	Dam on South branch – some positives and negatives	-	Some increase

Table 24: Estimated change in energy use and generation in CWMS Scenario 1

Expressed as MW	Current				Scenario 1						Net change in energy use (GW/annum)
	Existing SW energy use (GW/annum)	Energy use by groundwater in upper zone (GW/annum)	Existing GW energy use (GW/annum)	Total energy use (GW/annum)	New SW area energy use (GW/annum)	Energy use by groundwater in upper zone (GW/annum)	Energy use by new GW area (GW/annum)	Total energy use (GW/annum)	Other energy	Note	
Opuha command area	20.2	0.0	66.0	86.1	89.9	0.0	45.2	135.1	106.9	Lost generation from Waitaki and new generation at Burkes Pass	155.9
Mid Canterbury / South Rangitata	55.7	109.7	126.2	291.6	0.0	0.0	136.2	136.2			-155.4
Central	15.7	120.5	58.4	194.6	0.0	0.0	108.0	108.0			-86.6
North Waimak	23.6	27.4	12.1	63.1	0.0	0.0	41.7	41.7	-50.0	Lees valley dam	-71.3
Waipara	0.8	0.0	5.7	6.5	1.0	0.0	4.3	5.3			-1.2
North Canterbury	15.9	0.0	12.9	28.8	0.0	0.0	9.2	9.2			-19.6
<b>Total</b>	<b>131.9</b>	<b>257.6</b>	<b>281.2</b>	<b>670.7</b>	<b>90.9</b>	<b>0.0</b>	<b>344.7</b>	<b>435.6</b>	<b>56.9</b>		<b>-178.2</b>

## **Disclaimer**

The information collected and presented in this report and any accompanying documents by the consultant and supplied to Environment Canterbury is accurate to the best of the knowledge and belief of the consultant and subconsultants. While the consultant and subconsultants have exercised all reasonable skill and care in the preparation of information in this report, neither the consultant/subconsultants nor Environment Canterbury accept any liability in contract, tort or otherwise for any loss, damage, injury or expense, whether direct, indirect or consequential, arising out of the provision of information in this report.

Readers should note that the modelling has been undertaken for the purposes of high level strategic decision making, and makes coarse assumptions about various relationships between factors and costs. The modelling is not suitable for decision making on specific schemes, developments or farm level decisions, and the results should not be relied on for those purposes.

## Annex 1: Storage relationships

Figure 1: Area Reliability relationships Lees Valley

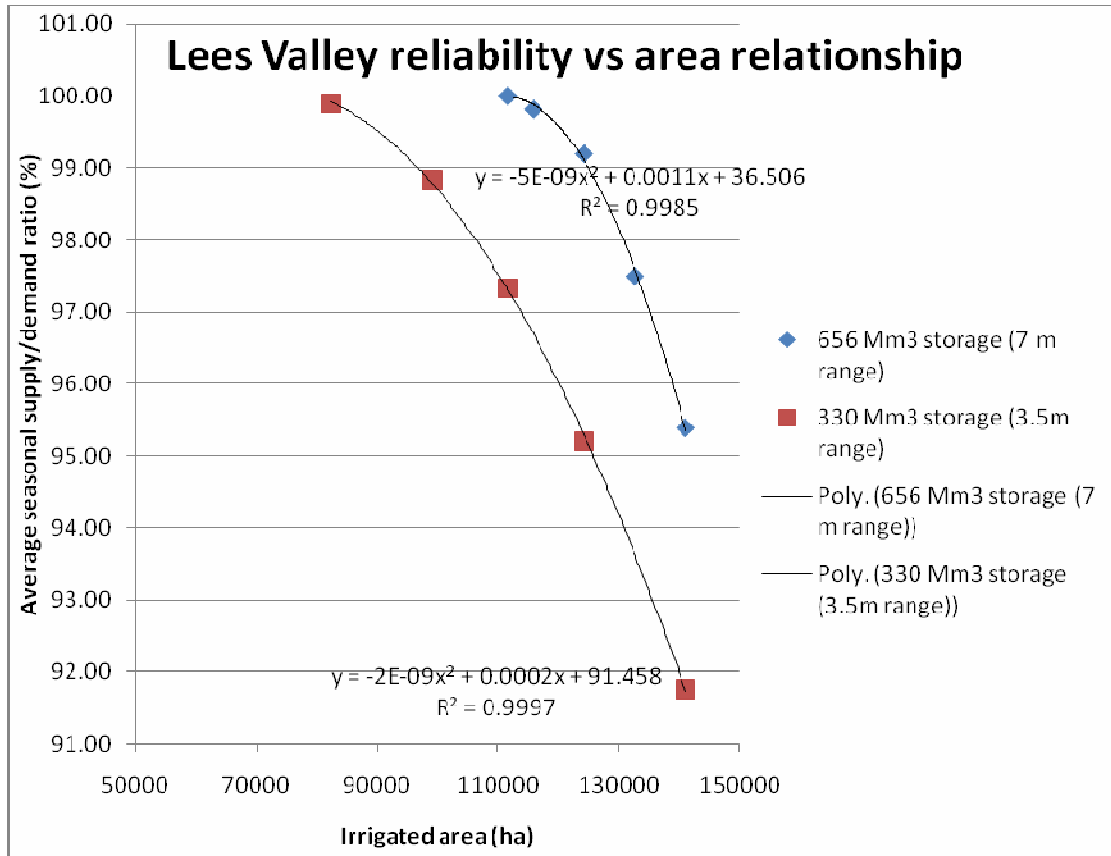


Figure 2: Area Reliability relationship for Coleridge

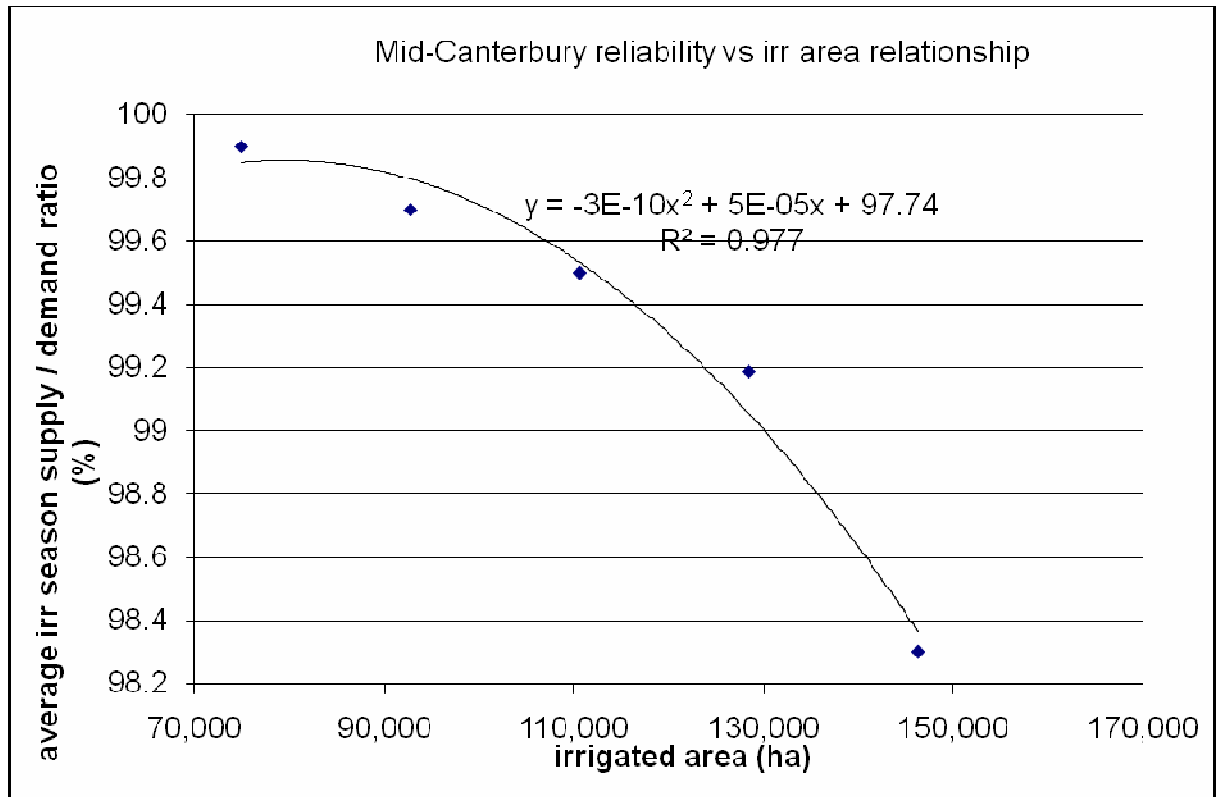


Figure 3: Reliability Area relationships for Hurunui South Branch 90 million m3

