Resource Economics

Essential Freshwater Package: *Costs Analysis*

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Report prepared for

Ministry for the Environment

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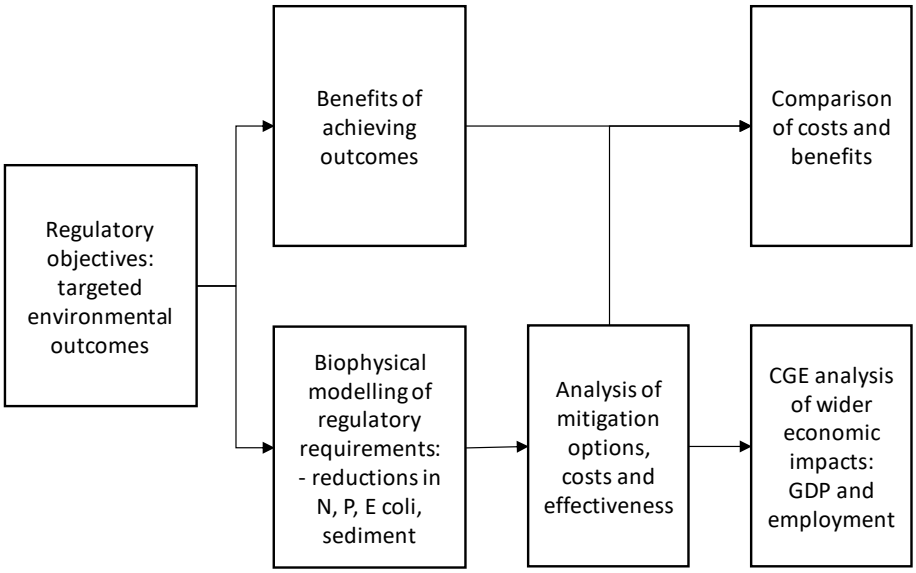
Contents

1 Introduction

1.1 Components

This report sets out the analysis used to assess the costs of components of the Essential Freshwater (EFW) Package. The components analysed are those requested by the Ministry for the Environment (MfE) and which were the subject of public consultation. The analysis described in this report fits into an impact analysis that includes the components shown in Figure 1.

Figure 1 Components of the analysis



The **regulatory objectives** are specified as targeted environmental outcomes. These include required practices, eg stream fencing to exclude stock, and environmental standards ('bottom lines' for N, P, *E coli* and MCI)[1].

Assuming full compliance, these environmental outcomes provide the basis for estimating the benefits of the package. The benefit analysis[2] includes some quantification of outcomes and some qualitative discussion of effects.

The objectives are also used to estimate the required reductions in discharges from land to meet these requirements. This is based on **biophysical models** which relate land use and discharge rates to concentrations in waterways.

The analysis of mitigation **options, costs and effectiveness** is undertaken to estimate the costs of meeting the regulatory requirements, by land use type and by region.

These costs are combined with the estimate of benefits in a **cost benefit analysis (CBA).** It includes an analysis of how costs and benefits change over time and the future costs and benefits are discounted to produce a net present value of the regulatory package.

[1] MCI = Macroinvertebrate Community Index, a measure of ecological health of a water body
[2] Denne (2020)

The cost analysis results are also used as input to a computable general equilibrium (CGE) analysis, used to assess the **effects across the economy** as a whole. This includes estimates of the impacts on GDP and employment and the way in which resources are reallocated within the economy because of changes in relative prices.

1.2 Defining the Regulatory Requirements

1.2.1 Existing Policy – the NPS-FM

Freshwater management is the responsibility of councils under the Resource Management Act 1991. National direction is provided through the National Policy Statement for Freshwater Management (the NPS-FM). Originally introduced in 2011, the NPS-FM was amended in 2014 and in 2017. Councils must fully implement the objectives and policies of the NPS-FM by 2025, or by 2030 if they cannot complete the process to sufficient quality by 2025.

Despite its recent commencement, a review of the NPS-FM after its introduction suggested it would not achieve the sustainable management of freshwater resources.[3] MfE suggests the problems include:

- problems with interpretation and implementation, including poor engagement with iwi/hapū in some locations;
- few regulatory options for councils to use to influence or control activities with the most impact on water quality, particularly agriculture; and
- standards not stringent enough – slow adoption of quantitative and enforceable water quality limits in the majority of regional plans, and the slow application of these limits to resource users.

The result of these shortcomings is that water quality is continuing to degrade in places, or it is expected to take a long time to achieve desired outcomes.

1.2.2 The Essential Freshwater Package

In response to the problems identified with the NPS-FM, the EFW package as proposed in 2019,[4] and currently undergoing modification, would introduce a new set of regulatory requirements, including tightened standards (or bottom lines), and more controls over farm management via requirements for stock exclusion from riparian strips. It aims:

- in the short run, to stop further degradation of freshwater quality and to start making improvements so water quality is materially improving within five years; and
- in the longer run, to bring freshwater resources, waterways and ecosystems to a healthy state within a generation.

It will also address water allocation issues.

[3] Ministry for the Environment (2019c)
[4] Ministry for the Environment (2019a)

Three regulatory tools have been identified.[5]

- changes to the NPS-FM;
- the creation of a new National Environmental Standard (NES) (which would impose regulations quickly to limit potential further decline); and
- the creation of new regulations[6] (which can take immediate effect from their commencement date and are a more appropriate vehicle for some interventions).

They would be expected to improve policy direction, set thresholds or bottom lines, require adoption of good practice, improve monitoring and reporting on freshwater, and support people in implementing these changes. These include:

- **Nitrogen and Phosphorus**:
    - more stringent bottom-lines for Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorus (DRP) which will apply in soft-bottomed rivers in some lowland agriculturally-dominated areas; and
    - reducing excessively high nitrogen leaching (a nitrogen cap) eg using per-hectare nitrogen leaching thresholds (option 1) and a national fertiliser cap (option 2);

- **Sediment:** bottom lines for sediment which will require reductions in erosion;

- ***E coli*:** a requirement to set target states for *E coli* above a national bottom line of 550 *E coli* per 100 ml for primary contact sites during the swimming season;

- **Māori values:** creating a 'mahinga kai' compulsory value and a new value category for 'tangata whenua' values in the National Objectives Framework;

- **Wetlands:** new rules to prevent further loss and degradation of remaining natural wetlands;

- **Stock exclusion**: regulations requiring farmers to exclude all cattle, pigs and deer from rivers, lakes, wetlands and drains across low-slope New Zealand.

1.3 Biophysical Modelling

As part of the impacts analysis, several biophysical models have been used to assess the mitigation or discharge reduction requirements to meet the different objectives of the policy package, including those relating to sediment[7] and stock exclusion.[8] In this section we summarise the work undertaken by NIWA as input to the analysis of the costs of the N & P bottom lines. The cost analysis for achieving those bottom lines is also included in this report.

[5] Ministry for the Environment (2019c)
[6] The regulations would be under Section 360 of the Resource Management Act 1991.
[7] Hicks *et al* (2019)
[8] Hicks (2020)

1.3.1 N & P Bottom Lines

Using its Catchment Land Use for Environmental Sustainability (CLUES) model,[9] NIWA modelled the reductions required in N & P to meet the requirements of the NPS-FM and the EFW bottom lines under different assumptions.

- Periphyton spatial exceedance criteria. This specifies, for locations that comply with the total nitrogen (TN) concentration target, the risk of exceeding the bottom line for periphyton.[10] The options modelled by NIWA include exceedance percentages of 10%, 20% (which is the base case assumption) and 30%.

- DIN bottom lines, specified as 1.0, 2.4 or 3.8 mg per litre, with 1.0mg/l as the base case assumption.

The CLUES model does not include any estimate of a change over time in levels of discharge in the baseline, ie in the absence of additional policy. This means the discharge reductions are all relative to current discharge rates based on monitored concentrations in 2013-2017. The CLUES results were provided for the terminal reaches of all sea-draining catchments (a total of 11,186); these are aggregated to the regional level in Table 1 for N and in Table 2 for P. The target reductions are the required reductions below the baseload. For example, in Northland, under the DIN1.0/Peri10 assumption, N must be reduced by 1,244 tonnes below the baseload level of 14,365 tonnes, ie a final discharge level of 13,121 tonnes. The largest reduction requirements are in Canterbury, Southland and the Waikato for N, and in Manawatu-Wanganui for P.

Table 1 Baseload total N discharges (tonnes) and targeted reductions below baseline (EFW)

Region	No policy baseline	Target Reductions				
		DIN1.0 + Peri10	DIN1.0 + N Peri20	DIN1.0 + N Peri30	DIN2.4 + N Peri20	DIN3.8 + N Peri20
Northland	14,365	1,244	124	82	67	66
Auckland	4,460	447	169	86	112	111
Waikato	38,377	7,743	3,808	3,373	1,294	1,231
Bay of Plenty	13,057	1,038	300	272	155	155
Gisborne	4,482	596	9	2	9	9
Taranaki	14,484	4,934	1,696	995	1,556	1,556
Manawatu-Wanganui	21,261	5,984	1,147	1,061	918	918
Hawke's Bay	12,672	2,609	1,008	928	891	891
Wellington	6,918	1,184	172	127	158	158
Tasman	3,352	52	9	7	3	3
Nelson	139	9	0	0	0	0
Marlborough	2,638	92	15	12	4	4
West Coast	21,875	83	22	21	19	19
Canterbury	33,355	13,140	10,690	9,358	8,671	8,113
Otago	17,572	2,958	680	317	577	544
Southland	26,690	8,376	4,282	2,321	3,704	3,677
Total	235,698	50,488	24,131	18,961	18,138	17,454

[9] CLUES is a GIS-based catchment model for predicting water quality and socio-economic indicators as a function of land use in New Zealand (Elliot *et al*, 2011)
[10] Ministry for the Environment (2019a)

	21.4%	10.2%	8.0%	7.7%	7.4%

Source: NIWA

Reductions in discharges increase over time; the assumptions are discussed in Section 2.3.1 below. The assumed rates of reduction in discharge below the baseline (which is assumed to be constant over time) are shown in Figure 2 for N; the same patter of reduction is assumed for P also.

Figure 2 Reductions in N discharges over time

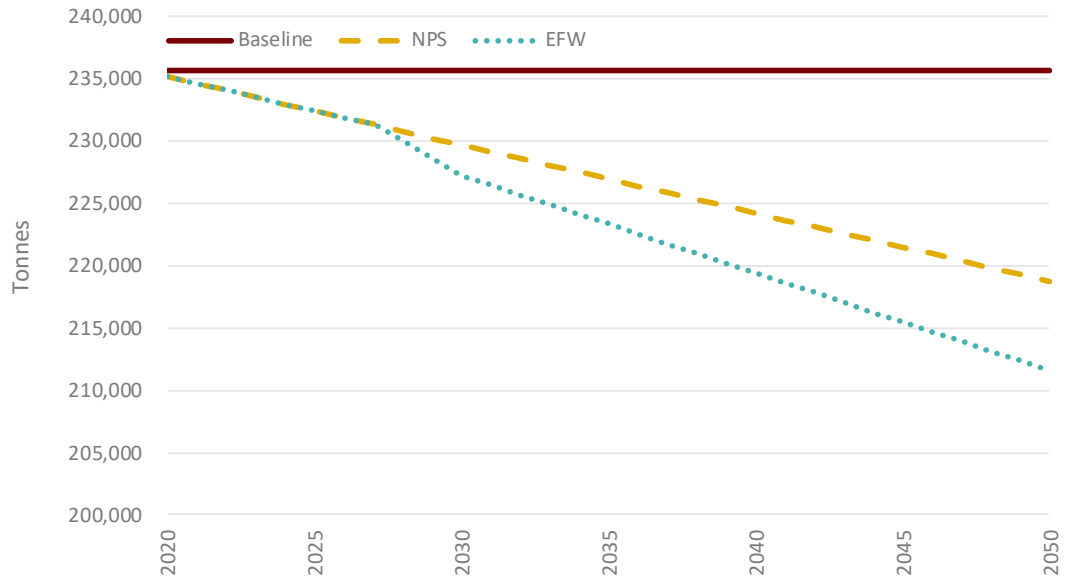


Table 2 Baseload total P discharges and targeted reductions (EFW)

Region	No policy baseline P (tonnes)	Targets		
		P Peri10	P Peri20	P Peri30
Northland	1,865	412	162	138
Auckland	565	83	36	22
Waikato	2,569	775	374	358
Bay of Plenty	2,990	414	148	122
Gisborne	10,233	461	20	11
Taranaki	1,155	355	48	45
Manawatu-Wanganui	3,640	1,410	333	364
Hawke's Bay	2,956	582	114	81
Wellington	1,060	344	36	27
Tasman	603	28	5	5
Nelson	22	5	0	0
Marlborough	616	147	15	21
West Coast	15,579	12	0	0
Canterbury	3,262	112	23	14
Otago	3,744	409	50	19
Southland	4,106	372	50	27
Total	54,964	5,923	1,417	1,254
		10.8%	2.6%	2.3%

Source: NIWA

Different amounts were targeted under the NPS-FM (Table 3).

Table 3 Targeted reductions from no policy baseline under NPS-FM

Region	N Peri10	N Peri20	N Peri30	P Peri10	P Peri20	P Peri30
Northland	1,186	66	24	287	37	3
Auckland	389	111	21	73	26	6
Waikato	5,229	1,231	782	506	65	52
Bay of Plenty	1,021	155	20	382	30	0
Gisborne	596	9	2	459	18	9
Taranaki	4,854	1,556	127	349	18	1
Manawatu-Wanganui	5,980	918	379	1,407	88	17
Hawke's Bay	2,599	891	320	581	85	2
Wellington	1,184	158	97	344	14	3
Tasman	46	3	0	24	0	0
Nelson	9	0	0	5	0	0
Marlborough	88	4	1	147	2	0
West Coast	80	19	18	12	0	0
Canterbury	10,170	7,610	5,900	108	15	3
Otago	2,861	544	122	403	41	2
Southland	7,816	3,677	862	370	40	2
Total	44,106	16,951	8,675	5,457	480	101

Source: NIWA

1.3.2 Land Uses

In addition to the discharge reduction requirements, catchment-level data were provided by NIWA on land use in 16 categories (Box 1 and see Annex A).

Box 1 Land use types in NIWA's output

Dairy	Plantation Forests	Arable	Tussock
Sheep & beef - Intensive	Horticulture	Other pasture	Urban
Sheep & beef – hill	Deer	Lifestyle	Water
Sheep & beef – high country	Other animal	Scrub & native forest	Other

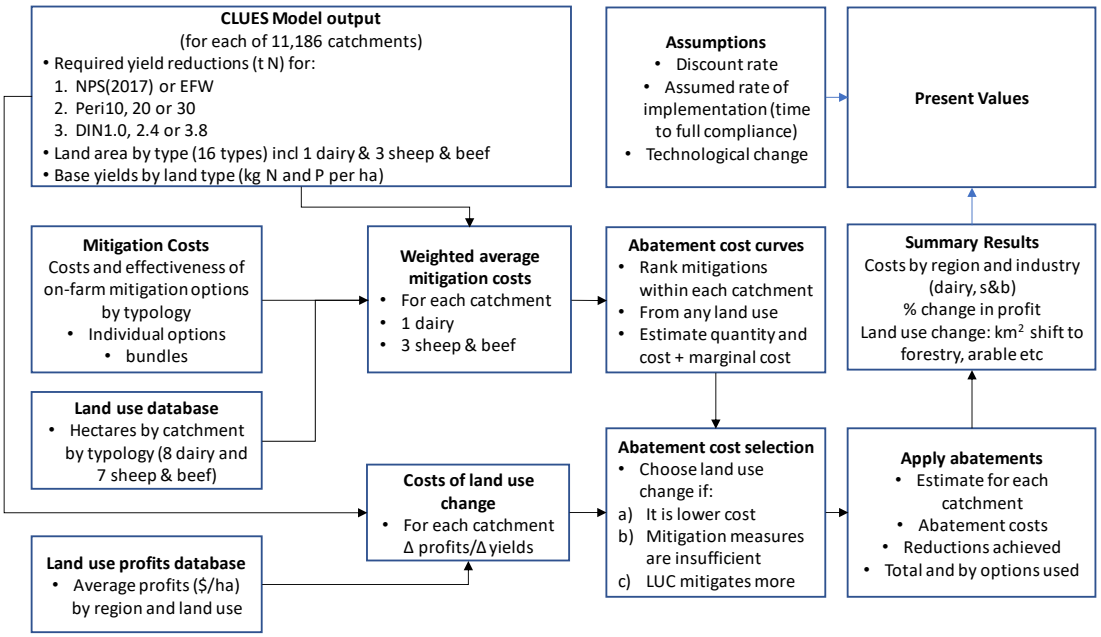
This provided the basis for the economic modelling which assessed the costs of reducing discharges by land use type.

2 Cost Analysis of N and P Bottom Lines

2.1 Approach

The costs analysis of N and P bottom lines involved the development of a bespoke model (Figure 3). It estimates the least cost achievement of the bottom line in each catchment and sums the results to the regional level, including the costs by land use type (eg dairy, plus intensive, hill country and high country sheep & beef) and whether they are for on-farm mitigations or land use change.

Figure 3 Cost analysis model



The model estimates the extent (and direction) of land use change in each catchment and this is summarised by region. The results are summarised as the total costs when policies are fully implemented and the present value of costs to full implementation under different discount rates and assumptions about the rate of technological development. Sensitivity analysis is undertaken on the target levels resulting from the different assumptions.

The model takes outputs from NIWA's CLUES model. This comprises estimates of the required reductions in discharges for each of 11,186 catchments. The reduction requirements are for full implementation against current estimated levels of discharge. Data are also provided on the area in each catchment by land use type (see Annex A which summarises the land use to a regional level), with the assumption that mitigation can occur on any tract of land in the catchment.

The extent of required discharge reduction changes over time (see Figure 2 above). The model estimates the least cost way to achieve reductions in 2050 and then scales those costs to estimate the costs in every other year.

2.2 Discharge Reduction Costs

2.2.1 Mitigation Cost Data

Mitigation costs and effectiveness assumptions are inputs to the model. The analysis included a review of individual studies of the costs of mitigation in specific regions or catchments.[11] However, the analysis required data that could be used to provide a comprehensive and consistent set of costs and effectiveness assumptions for all parts of New Zealand.

Effectiveness assumptions were provided to the study team and MfE by AgResearch including assumed effectiveness rates for individual mitigation actions and for 'bundles' of actions.[12] Costs were supplied for a selection of individual measures by PerrinAg consultants. These provided an initial dataset for model construction. However, because they were limited in scope and number, an alternative source was used for the costs of bundles of measures, as is common in other studies. The AgResearch effectiveness numbers for specific land typologies were combined with cost and effectiveness estimates by Landcare Research, Motu and NIWA.[13] Using these sources, MfE constructed assumptions for mitigation bundles, labelled M1, M2 and M3. The assumed components of these bundles are set out in Table 4.

Table 4 Potential components of mitigation bundles

Bundle	Management Option[1]
M1	**Relatively cost-effective measures with minimal complexity to existing farm systems & management** • Installation of soil moisture monitoring gear and VRI on existing centre pivots. • Adjust cropping fertiliser rates and types to best suit plant requirements and timings. • Limit each urea application • Variable Rate Fertiliser. • Gibberellic Acid to substitute some spring and autumn nitrogen on pastures. • Apply nitrate inhibitors • Optimise Stocking Rates • Implement best management practices for infrastructure use and maintenance • Optimum Olsen P • Low solubility P fertiliser • Laneway runoff diversion • Effluent management • Stock exclusion/fencing
M2	**Less cost-effective than M1, requiring limited capital costs or systems change** • Modify irrigated area to include centre pivots/laterals fitted with Variable Rate Irrigation technology. • Variable Rate application of liquid urea. • Wetlands and/or sediment traps • Tile drain amendments • Reduce nitrogen fertiliser applications • Riparian planting • Enhance animal productivity via introducing cows with greater genetic merit • Dairy farms to install covered feed pads and required effluent systems.
M3	**Options with large capital costs and/or are relatively unproven** • Further reduce nitrogen fertiliser applications • Reduce stocking rates • All cows wintered off paddock, possibly in barns

[11] See, for example Matheson *et al* (2018a; 2018b); Olubode-Awosola et al (2014); Daigneault et al (2013)
[12] Richard McDowell (personal communication); McDowall *et al* (in prep)
[13] Daigneault *et al* (2016)

- Restricted grazing of pasture and cropland
- Apply alum to pastures and crops
- Increase effluent area
- No winter feed crop yields over 14t/ha.

[1] A bundle will not necessarily include all of these practices, but rather a mix that achieves a similar reduction in contaminants for a given annualised cost per ha.
Source: Daigneault et al (2016)

The effectiveness and cost assumptions are shown in Table 5 for dairy and in Table 6 for sheep & beef, deer and horticulture. The effectiveness percentages are the reductions in discharge levels relative to the base case, so a bundle with 5% effectiveness would reduce a baseline discharge rate of 20kgN/ha to 19kg/ha.

Table 5 Cost and effectiveness assumptions for dairy for three bundles of measures (N reduction)

					Effectiveness			Costs (2019$/ha)		
Type	**Location**	**Slope**	**Drainage**	**Wetness**	**M1**	**M2**	**M3**	**M1**	**M2**	**M3**
D1	NI	Flat	Poor	Any	5.7%	8.4%	26.9%	$11	$35	$687
D2	NI	Flat	Other	Any	11.0%	0.0%	27.1%	$11	$35	$687
D3	NI	Moderate	Poor	Any	5.0%	6.5%	22.0%	$11	$35	$687
D4	NI	Moderate	Other	Any	9.0%	13.3%	22.2%	$11	$35	$687
D5	SI	Flat	Poor	Any	17.4%	5.0%	38.3%	$11	$35	$687
D6	SI	Flat	Other	Un-irrigated	12.1%	0.0%	24.0%	$11	$35	$687
D7	SI	Flat	Other	Irrigated	22.0%	0.0%	37.0%	$11	$35	$687
D8	SI	Moderate		Any	13.5%	2.7%	27.6%	$11	$35	$687

Source: MfE (adapted from Daigneault et al (2016) and McDowall et al (in prep); costs inflated to 2019$ from 2012$ in Daigneault et al using PPI[14]

The costs in the tables are the estimated marginal costs and effectiveness for the bundles. They are based on the figures in Daigneault et al (2016) who present the bundle cost and effectiveness numbers as aggregates in which M2 also includes the practices in M1, while M3 includes practices from M1 and M2. Our numbers represent the additional effects (costs and effectiveness) of moving from M1 to M2 and from M2 to M3.

Table 6 Cost and effectiveness assumptions for sheep & beef for three bundles of measures (N reduction)

			Effectiveness			Costs (2019$/ha)		
Type	**Category**	**Location**	**M1**	**M2**	**M3**	**M1**	**M2**	**M3**
SB1	Hill	SI	19%	5%	15%	$20	$7	$19
SB2	High Country	SI	19%	2%	15%	$20	$7	$19
SB3	Hard Hill	NI	19%	2%	15%	$20	$7	$19
SB4	Hill	NI	19%	4%	15%	$20	$7	$19
SB5	Intensive Finishing	NI	19%	10%	15%	$20	$7	$19
SB6	Intensive Finishing	SI	19%	19%	15%	$20	$7	$19
SB7	Mixed Finishing	NZ	19%	19%	15%	$20	$7	$19
	Deer	NZ	19%	6%	15%	$80	$27	$80
	Horticulture	NZ	34%	3%	4%	$178	$244	$80

Source: MfE - adapted from Daigneault et al (2016) and McDowall et al (in prep); costs inflated to 2019$ from 2012$ in Daigneault et al using PPI

[14] PPI for agriculture, forestry and fishing (StatsNZ Table PPI019AA)

A simpler set of assumptions was made for P reduction costs and effectiveness (Table 7).

Table 7 Cost ($/ha) and effectiveness assumptions for three bundles of measures (P reduction)

	M1	M2	M3	M1	M2	M3
Dairy	$11	$35	$687	14%	16%	4%
Sheep & Beef	$20	$7	$19	35%	13%	10%
Deer	$80	$27	$80	35%	13%	10%
Crops & Horticulture	$178	$244	$80	56%	32%	0%

Source: MfE (adapted from Daigneault et al (2016) and McDowall et al (in prep); costs inflated to 2019$ from 2012$ in Daigneault et al using PPI

The costs are annualised costs and reflect assumptions on a combination of capital, maintenance and land use opportunity costs. These reflect specific assumptions used by Daigneault et al (2016), eg costs are annualised over 25 years using a discount rate of 8%. However, we have simply used their annualised costs rather than re-estimated these at different discount rates as used elsewhere in this report. This is largely because the authors do not provide sufficient detail to enable this.

The effectiveness assumptions are estimated for different bundles of mitigation measures, using assumptions from AgResearch.[15] These are based on analyses of the effectiveness of interventions under different land types, classified by characteristics of slope, drainage and wetness for dairy and land types for sheep & beef which largely reflect topology. Single land types are assumed for deer, crops and horticulture. The effectiveness assumptions have been combined by MfE with the cost data as shown above. We have adopted these assumptions for analysis.

To apply these cost and effectiveness data to the land use categories used by NIWA, weighted average costs of mitigation are estimated for each catchment. This estimated the dairy farm areas within each region that fall within the slope, drainage and wetness categories used for the dairy typologies (Table 5) and the sheep and beef land use classifications (Table 7).[16]

2.2.2 Land Use Change

Land use change is also an option and an alternative to the application of mitigation measures. The costs and effectiveness of land use change options are estimated as the change in profit per hectare (Table 8) divided by the change in yields (see Annex A for weighted average yields in kg/ha). The profits data are from a mix of sources, including published data from DairyNZ and Beef+Lamb NZ for dairy and sheep and beef respectively, a 2018 farm survey for arable benefits,[17] plus the analysis of ratios of regional land values to apply as multipliers to profits levels of land uses for which data were available. In the absence of more detailed information, we assume the same profit levels per hectare for every hectare of a specific land use within a region.

[15] Richard McDowell (personal communication); McDowall *et al* (in prep)
[16] Intensive sheep & beef is split between SB5 and SB7 in the North Island and between SB6 and SB7 in the South Island. Hill country sheep & beef is split between SB3 and SB4 in the North Island and is all treated as SB1 in the South Island; South Island high country sheep & beef is all SB2.
[17] Brown Glassford and Co Ltd (2018)

The analysis here does not include any additional costs associated with land use change. For example, for it to occur, it may require a change in landowner to someone who is better skilled at the alternative land use. Or it may require additional training costs. These costs are not estimated. This is a limitation to the study and may mean land use change costs are underestimated, unless these costs are accounted for in differences in land values.

Table 8 Land use profits ($/ha per annum)

Region	Dairy	SB Intensive	SB Hill	SB High	Arable	Forestry	Horticulture	Deer
Northland	$1,234	$468	$250		$1,047	$787	$6,417	$1,308
Auckland	$1,234	$468	$250		$1,047	$188	$6,947	$1,290
Waikato	$1,606	$468	$250		$1,047	$323	$4,468	$1,087
Bay of Plenty	$1,591	$279	$246		$1,047	$448	$7,411	$887
Gisborne	$1,591	$279	$246		$1,047	$746	$5,944	$813
Taranaki	$1,576	$303	$237		$1,047	$318	$2,778	$671
Manawatu-Wanganui	$1,614	$279	$246		$1,047	$434	$9,596	$2,556
Hawke's Bay	$1,614	$279	$246		$1,047	$655	$4,431	$847
Wellington	$1,614	$279	$246		$1,047	$440	$4,537	$2,311
Tasman	$1,090	$276	$80	$80	$1,047	$620	$2,716	$1,195
Nelson	$1,090	$276	$80	$80	$1,047	$506	$1,631	$932
Marlborough	$2,174	$276	$80	$80	$1,047	$1,271	$2,303	$632
West Coast	$1,090	$328	$80	$80	$1,047	$608	$4,431	$847
Canterbury	$2,174	$276	$80	$80	$1,047	$469	$3,637	$1,234
Otago	$1,745	$328	$80	$80	$1,047	$504	$3,329	$901
Southland	$1,745	$328	$80	$80	$1,047	$462	$2,165	$850

Source: DairyNZ; Beef + Lamb NZ; Brown Glassford and Co Ltd (2018); analysis of land values

Some constraints to land use change are assumed. It is assumed that there can be no change in land use from dairy to forestry in Canterbury and shifts to arable land is assumed to occur only in catchments in which there is arable land currently.

2.2.3 Discharge Reduction Cost Curves and Abatement Choice

The data in Table 5 to Table 8 are used to estimate costs of mitigation as $/kg of N and P reduced, for each mitigation bundle, for each land use type for each catchment.

Cost curves are then calculated for each catchment by ranking each abatement opportunity from least to highest cost (apart from where one is dependent on another). The abatement could occur on any land use type. They continue to be added until options are exhausted, or the target reduction is achieved.

The choice of abatement between land use change and on-farm mitigation uses the following rules. Land use change is used if all three of the following conditions apply:

- Other mitigation measures are insufficient to achieve the target reduction for the catchment;

- Land use change will result in more discharge reduction than the mitigation measures would have achieved, ie it is more effective; and

- Land use change is lower cost than the marginal cost of the mitigation measures.

2.3 Model Assumptions

Several assumptions are important to the model runs and results.

2.3.1 Constant Baseline

The discharge reduction data provided by NIWA assume no change in discharge levels from catchments over time. This is a simplification that avoids making assumptions about land use change or changes in land use productivity or management practices. We have carried these assumptions over to the cost modelling. This does not matter if the focus of attention is on the differences in results between the costs associated with the NPS-FM and the EFW, rather than the absolute costs of either of these policy packages.

2.3.2 Rate of Policy Implementation

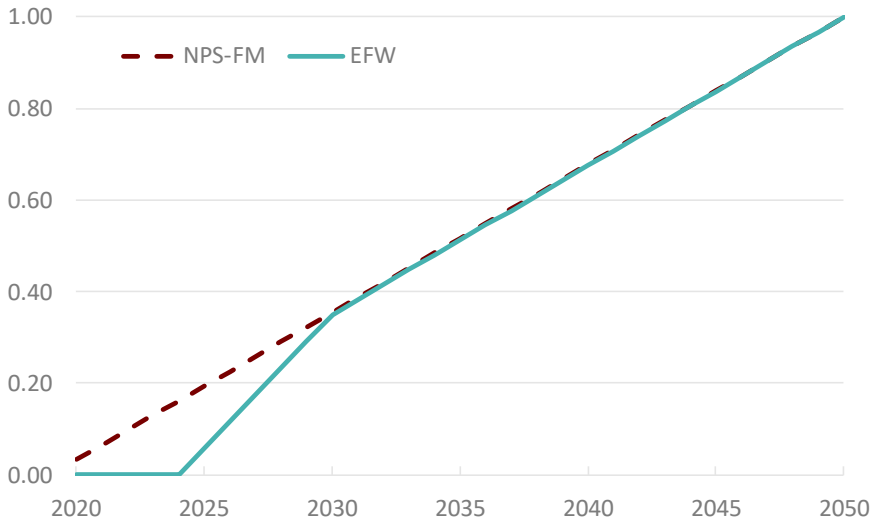
To estimate the present value of costs over time, the costs are multiplied by an assumed degree of implementation in each year. This assumes both the NPS-FM and the Essential Freshwater (EFW) package would be introduced steadily over time. The assumptions are shown in Figure 4.

- The NPS-FM is assumed to be introduced in a straight line between now and 2050.

- The EFW is assumed to be introduced rapidly from 2025 so that it is 35% implemented by 2030. It is then introduced in a straight line to achieve full implementation in 2050.

However, for modelling purposes, rather than assume nothing happens under the EFW scenario until 2025, the assumption is that the same effort (and costs) as assumed under the NPS-FM occurs.

Figure 4 Assumed rate of implementation



Present values (PVs) are estimated at different discount rates and different assumptions over technological change. We discuss these parameters below.

The PV analysis is to 2050 at which time full implementation is expected. This assumes that policies introduced locally to encourage discharge reduction continue over time, such that the incentives remain for changes to be permanent once made. The analysis stops at 2050, somewhat arbitrarily. It is assumed that by this time (30 years from now) it would be reasonable to assume some reappraisal of policy or changes in land use based on exogenous factors such that the underlying assumptions (current discharge rates under the no policy counterfactual) become highly uncertain. This latter point is especially relevant with low discount rate assumptions.

2.3.3 Discount Rate

In this analysis we use a central discount rate of 3% and with sensitivity analysis using 0%, 1% and 6%. Below we briefly discuss the basis for these rates.

Rationale for Discounting

When analysing costs and benefits in a CBA for policy purposes, we are measuring changes in total community wellbeing. Wellbeing is assumed to be the result of 'consumption', using a broad definition of that term. Freshwater policies have costs because they require more expenditure (on fences, supplementary feed etc) or result in reduced profits (eg because of lower stocking rates reducing total production); there are opportunity costs because the effect of these expenditures is to reduce the potential for consumption of goods and services that provide wellbeing. Similarly, on the benefits side, everything from which people obtain wellbeing is said to be 'consumed', eg people might 'consume' a view or the knowledge of water quality improvements in places they will never visit; the policies are expected to lead to increased consumption of environmental goods.

Wellbeing is affected by what people consume, how much they consume and when they consume. Discounting is a means of adjusting the size of costs and benefits that arise in different time periods to account for preferences over the timing of consumption.

Discounting is usually used to reduce the value of future costs and benefits. This is because people generally prefer to consume sooner rather than later and, consistent with assumptions of rational decision making, this is assumed to mean people obtain greater wellbeing benefits from earlier consumption. Although several authors have questioned whether time preference is rational (eg Pigou, 1932; Ramsey 1928)[18] and/or if it should be used for public decision making (Samuelson, 1937), mostly there is acceptance of a theoretical basis for using a discount rate greater than zero and for using it in public policy decision making.[19] For example, Nicholas Stern who examined the use of very low discount rates in the context of climate change policy affecting future generations, suggested a low but positive rate on the basis of some greater than zero probability of human extinction which favours current consumption.[20]

[18] Arthur Pigou (1932) argued that someone's satisfaction obtained from consuming this year rather than next, is balanced by the satisfaction obtained next year from consuming then, rather than this year! He suggests "*it implies that people distribute their resources between the present, the near future and the remote future on the basis of a wholly irrational preference*" (p25).
[19] Arrow *et al* (1995)
[20] Stern (2006)

Future generation issues are of less concern than they are for climate change because the effects on water quality are more reversible, although this differs by waterbody type with some potential irreversible or only slowly reversible effects particularly in lakes and estuaries.[21]

Methodologies

There have been two main methodologies for deriving a discount rate for public policy purposes.

- The **social rate of time preference** (SRTP) measures time preferences directly – how much people prefer to consume now rather than later. Because people usually prefer to consume earlier in time, and for adverse effects to be delayed, there is a cost when consumption is shifted to a later time, and a benefit when it is brought forward. SRTP analyses often also assume that people in the future will be richer and therefore the wellbeing gained from an additional dollar's worth of consumption will be less than it is for current (and assumed poorer) individuals.[22]

- The **social opportunity cost of capital** (SOC) examines returns on investment in which investing money, which might otherwise have been used to pay for consumption goods now, obtains a market return enabling greater future consumption.

The NZ Treasury has generally used the SOC as the basis for setting discount rates for use in public policy,[23] currently recommending use of a 6% default rate.[24] However, for sensitivity analysis they have used a 3% rate in their CBAx tool, which is a spreadsheet model that contains a database of values to help agencies measure impacts and undertake CBAs.[25] These discount rates are in real terms, ie they apply to monetary values using current dollars, so at 2% inflation they are equivalent to rates of approximately 7.9% and 4.9% in nominal terms.

Some studies in New Zealand have attempted to measure the SRTP, including a (real) rate of 4.4% estimated in 2006 for the national energy strategy,[26] a range of 2.7 to 4.2% developed in the context of decisions on investments in the national electricity transmission grid,[27] and 3% in a study relating to transport infrastructure investments.[28] Auckland Council adopted a rate of 4% for CBAs, building on advice from NZIER for a rate of between 3% and 4%.[29]

For analysis, we have adopted:

- a rate of 3% as the central discount rate. It reflects analyses of the SRTP in New Zealand and uses the low rate used by Treasury in in its CBAx model.

[21] See discussion in Graham *et al* (2020)
[22] Recent analyses in the context of climate change have questioned this assumption.
[23] NZ Treasury (2015)
[24] https://treasury.govt.nz/information-and-services/state-sector-leadership/guidance/financial-reporting-policies-and-guidance/discount-rates
[25] NZ Treasury (2019)
[26] Ministry of Economic Development (2006)
[27] Castalia (2006)
[28] Parker (2009)
[29] Chief Economist Unit (2013)

- a high rate of 6%, based on Treasury's default rate; and
- a low rate of 1% which takes account of impacts on future generations; and
- 0%, reflecting doubts over the rationality of discounting.

2.3.4 Technological Change

It is expected that, because of the increased investment in mitigation options to reduce discharged to waterways, there will be increased innovation and technological change. We examine the implications of this as a reduction in costs over time. We use this in sensitivity analysis, including assumed reductions of 1% and 1.75% per annum in the costs of on-farm mitigations.

2.4 Model Results

The abatement strategy, selected via the catchment-specific cost-curve, is applied to each catchment and the results are then summarised by region. The results include (1) costs of all mitigations, by land use type (dairy, sheep & beef), and by mitigation type (on-farm mitigation or land use change); and (2) the extent and direction of land use change. The summary results are for full implementation of the policies relative to current discharges.

2.4.1 Base Case Results

Annual Costs

The base case analysis assumes a DIN bottom line of 1.0mg/l and a periphyton spatial exceedance value of 20%.

The results are shown in Table 9, with more detailed results in Annex B. When fully implemented, which is not expected until 2050, total annual costs are estimated at $688 million. Costs would be expected to rise to this level over time as the policy is fully implemented (see Section 2.3.1), with annual costs of approximately $241 million in 2030 (Figure 5). The most significant costs are in Canterbury, Waikato and Southland, reflecting the significant level of targeted discharge reductions (Table 1).

The "other" category of costs is not a modelled result but is a residual. It is calculated by multiplying:

(1) the gap between the targeted reductions in discharge and what the identified measures (mitigation and land use change) are estimated to deliver; by
(2) the average costs of reducing discharges in each catchment across the mitigation and land use change actions which are modelled.

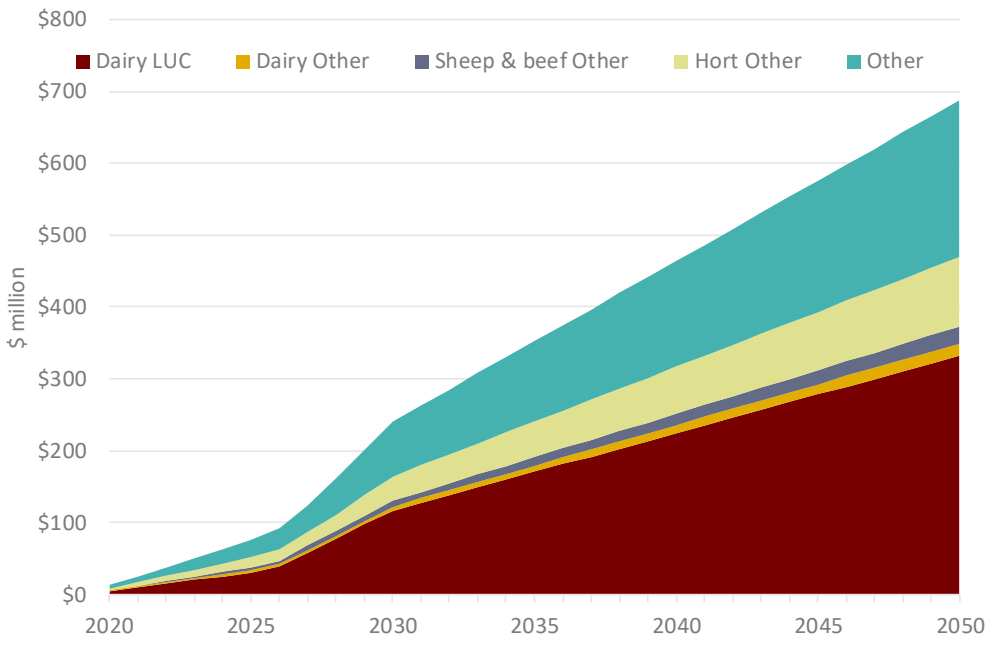
Thus, we do not know what land uses these reductions occur on, or what they consist of (or even if they can occur); it is a best estimate given the limited information in the model on mitigation options. An alternative way to have estimated these costs is to assume land use change from other land uses (other pasture, arable, other animal etc) to forestry. Land use change does not achieve the whole targeted discharge reduction currently because land use change is an option for a limited number of land uses for which we have estimated profit levels, and many catchments will not include sufficient land area in these modelled land use types.

It is not clear if using average costs will over- or under-estimate total costs Land use change costs may be lower for these other land uses because profitability is expected to be lower than for dairy (and thus lost profits will be lower). We do not have information on mitigation options or costs with which to estimate cost relativities.

Table 9 Base case - costs of EFW package in 2050 ($ million) when fully implemented – by land use and type

Region	Dairy	Sheep & beef	Horti-culture	Other	Total	Miti-gation	Land use change	Other
Northland	$1.4	$0.4	$0.0	$1.4	$3.2	$0.7	$1.1	$1.4
Auckland	$6.9	$1.0	$0.0	$1.6	$9.6	$0.5	$7.4	$1.6
Waikato	$150.0	$0.1	$0.0	$0.5	$150.6	$0.1	$150.0	$0.5
Bay of Plenty	$5.1	$0.1	$0.0	$2.3	$7.6	$0.8	$4.6	$2.2
Gisborne	$0.0	$0.5	$0.0	$0.8	$1.2	$0.5	$0.0	$0.8
Taranaki	$42.0	$0.0	$0.0	$8.3	$50.2	$0.1	$41.8	$8.3
MWT-WHG	$30.5	$1.7	$0.3	$4.3	$36.8	$2.0	$30.4	$4.3
Hawke's Bay	$0.2	$2.2	$3.0	$23.4	$28.8	$5.6	$0.0	$23.2
Wellington	$1.2	$0.4	$0.0	$1.4	$3.0	$0.4	$1.2	$1.4
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Marlborough	$0.0	$0.1	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1
Canterbury	$79.2	$5.5	$93.8	$140.3	$318.9	$107.0	$75.2	$136.6
Otago	$5.7	$4.0	$0.0	$0.4	$10.1	$8.8	$0.9	$0.4
Southland	$27.0	$8.0	$0.0	$32.6	$67.5	$16.4	$20.3	$30.9
NZ	$349.2	$24.1	$97.1	$217.7	$688.1	$143.2	$332.9	$211.9

Figure 5 Increase in annual costs ($ million) with implementation



Note: main cost categories included only

The costs in Table 9 are shown by broad land use type (dairy, sheep & beef, horticulture and other) and include the costs of land use change and of on-farm mitigations. The costs of land use change are the changes in profits from moving from a high value land use (eg dairy) to a lower value land use (eg forestry). The costs are presented as a net cost to dairy, although this is made up of the loss of dairy profit and a gain of forestry profit.

Table 9 shows the impacts of the EFW, but our interest is in the increase in costs relative to those from implementing the NPS-FM. The marginal costs are shown in Table 10. These are the additional costs of the EFW package above those already committed to through by the NPS-FM.

Table 10 Base case – marginal costs of EFW package ($ million) when fully implemented – by land use and type

	Dairy	Sheep & beef	Horti-culture	Other	Total	Miti-gation	Land use change	Other
Northland	$0.2	$0.0	$0.0	$0.3	$0.5	$0.0	$0.2	$0.3
Auckland	$3.0	$0.0	$0.0	$0.3	$3.3	$0.0	$3.0	$0.3
Waikato	$118.8	$0.0	$0.0	$0.1	$118.9	$0.0	$118.8	$0.1
Bay of Plenty	$3.9	$0.0	$0.0	$0.3	$4.2	$0.0	$3.9	$0.3
Gisborne	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1
Taranaki	$2.7	$0.0	$0.0	$3.1	$5.8	$0.0	$2.7	$3.1
MWT-WHG	$9.7	$0.0	$0.0	$0.7	$10.4	$0.0	$9.7	$0.7
Hawke's Bay	$0.0	$0.0	$0.0	$7.2	$7.2	$0.0	$0.0	$7.2
Wellington	$0.0	$0.0	$0.0	$0.3	$0.3	$0.0	$0.0	$0.3
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Marlborough	$0.0	$0.1	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0
West Coast	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Canterbury	$30.4	$0.1	$26.6	$64.8	$121.9	$27.9	$29.7	$64.3
Otago	$1.9	$0.9	$0.0	$0.1	$2.8	$2.0	$0.8	$0.1
Southland	$6.7	$0.0	$0.0	$11.6	$18.3	$0.0	$6.7	$11.6
NZ	$177.3	$1.1	$26.6	$89.0	$294.0	$29.9	$175.6	$88.5

The main additional costs are for Canterbury and Waikato regions. In Canterbury the additional costs are fairly equally spread between additional on-farm mitigations and land use change, whereas in Waikato the additional costs are from land use change. The estimated extent of land use change is shown in Table 11. Overall, there is an estimated additional 7% reduction in dairy land and a 5% increase in forestry. There is a very significant modelled increase in arable land area in Southland, although from a low base (6.8km^2 – see Annex A), and large increases in Canterbury and Otago. There is very little change predicted in the area in sheep & beef.

Table 11 Changes in land use – marginal effects of EFW over NPS-FM

Region	Dairy	Sheep & beef	Forestry	Arable
Northland	-0.3%	0.0%	0.3%	0.0%
Auckland	-6.2%	-0.1%	5.8%	0.0%
Waikato	-15.6%	0.0%	28.2%	0.0%
Bay of Plenty	-3.4%	0.0%	1.2%	0.0%
Gisborne	0.0%	0.0%	0.0%	0.0%
Taranaki	-1.0%	0.0%	7.1%	0.0%
Manawatu-Wanganui	-5.0%	0.0%	5.2%	0.0%
Hawke's Bay	0.0%	0.0%	0.0%	0.0%
Wellington	0.0%	0.0%	0.0%	0.0%
Tasman	0.0%	0.0%	0.0%	0.0%
Nelson	0.0%	0.0%	0.0%	0.0%
Marlborough	0.0%	0.0%	0.0%	0.0%
West Coast	0.0%	0.0%	0.0%	0.0%
Canterbury	-10.2%	0.1%	0.0%	49.7%
Otago	-0.8%	0.0%	0.0%	28.4%
Southland	-4.8%	0.0%	0.0%	1414.4%
NZ	-7.1%	0.0%	5.2%	59.0%

Present Value

Table 12 shows the annual cost estimates and the present value (PV) of costs to 2050, for the NPS-FM and the EFW, and the difference between them.

Table 12 Annual and PV of costs to 2050 ($ million)

	Annual costs NPS-FM	Annual costs EFW	Annual costs - difference	PV NPS-FM	PV EFW	PV difference
Dairy	$172	$349	$177	$1,561	$2,975	$1,413
Sheep & Beef	$23	$24	$1	$209	$217	$7
Hort	$70	$97	$27	$640	$845	$205
Other	$129	$218	$89	$1,169	$1,869	$700
Total	$394	$688	$294	$3,579	$5,905	$2,326

The PV of costs is also estimated using different discount rates, as discussed in Section 2.3.3. Table 13 shows the PV for the difference in costs from 2020 to 2050 at 3%, 0%, 1% and 6% discount rates. The base estimate of costs is $2.3 billion, varying from $4.3 billion (zero discount rate) to $1.3 billion (at 6%). The main costs fall on the dairy sector, although there are significant costs only identified as “other”, which is a category of unknown costs (the gap to meet targeted reductions times average costs of reducing discharges for the identified sectors).

Table 13 Present value of costs - marginal costs of EFW ($ million)

	0%	1%	3%	6%
Dairy	$2,604	$2,112	$1,413	$808
Sheep & Beef	$14	$11	$7	$4
Hort	$382	$309	$205	$116
Other	$1,296	$1,049	$700	$398
Total	$4,296	$3,481	$2,326	$1,326

Below we first compare the results with the recent analysis by DairyNZ. We then undertake sensitivity analysis on assumptions relating to:

- Spatial exceedance criteria (sensitivity) for periphyton;
- DIN bottom line;
- Technical efficiency.

2.4.2 Cost Comparison to Previous Analyses

Table 14 shows the impacts of the costs discussed above on sectoral profits. The effects are significantly lower than those estimated by Doole (2019); he estimates dairy profits would be negative in Northland and Taranaki regions by 2045-50, would fall by 70% in Waikato, and by 50% in both Canterbury and Southland. This reflects a number of differences in the analyses.

- We assume least cost reduction in discharge across every catchment. This includes a mix of on-farm mitigations and land use change;
- On-farm mitigations are applied as bundles, enabling significant levels of discharge reduction;
- Land use change from dairy (or sheep & beef) is to some other productive (and profit-producing) land use, rather than non-use.

Table 14 Estimated impact on sectoral profits

	NPS-FM		EFW		Difference	
Region	**Dairy**	**Sheep & beef**	**Dairy**	**Sheep & beef**	**Dairy**	**Sheep & beef**
Northland	0.5%	0%	0.6%	0%	0.1%	0.0%
Auckland	6.9%	2%	12.1%	2%	5.2%	0.0%
Waikato	3.3%	0%	15.7%	0%	12.5%	0.0%
Bay of Plenty	0.8%	0%	3.2%	0%	2.4%	0.0%
Gisborne	0.2%	1%	0.2%	1%	0.0%	0.0%
Taranaki	11.6%	0%	12.4%	0%	0.8%	0.0%
Manawatu-Wanganui	7.9%	1%	11.5%	1%	3.7%	0.0%
Hawke's Bay	0.5%	1%	0.5%	1%	0.0%	0.0%
Wellington	1.9%	1%	1.9%	1%	0.0%	0.0%
Tasman	0.1%	0%	0.2%	0%	0.1%	0.0%
Nelson	0.0%	2%	0.0%	2%	0.0%	0.0%
Marlborough	0.0%	0%	0.0%	0%	0.0%	0.3%
West Coast	0.1%	0%	0.1%	0%	0.0%	0.0%
Canterbury	8.9%	3%	14.4%	3%	5.5%	0.1%
Otago	1.6%	1%	2.4%	2%	0.8%	0.3%
Southland	5.7%	5%	7.6%	5%	1.9%	0.0%
Total	5.1%	1%	10.3%	2%	5.3%	0.1%

2.4.3 Sensitivity Analysis: Periphyton spatial exceedance criteria

We examine the effects on costs of changing the assumptions on periphyton sensitivity, which is effectively a measure of the effectiveness of council monitoring systems.[30] The base case analysis has assumed 20% sensitivity; below we test 10% and 30% sensitivity. The implications

[30] This specifies, for locations that comply with the total nitrogen (TN) concentration target, the risk of exceeding the bottom line for periphyton.

of the lower (10%) sensitivity are that the discharge reduction targets are more stringent, resulting in a greater requirement for mitigation and for costs.

The detailed results are provided in Annex B with a summary of annual (2050) costs for the NPS-FM and EFW in Table 15, and the differences in annual and the PV to 2050 in Table 16.

Table 15 Annual costs (in 2050) ($million) of different periphyton spatial exceedance criteria assumptions for NPS-FM and the EFW

Land use	NPS-FM @ 10%	NPS-FM @ 20%	NPS-FM @ 30%	EFW @ 10%	EFW @ 20%	EFW @ 30%
Dairy	$788	$172	$78	$945	$349	$282
Sheep & Beef	$154	$23	$8	$154	$24	$13
Horticulture	$90	$70	$67	$117	$97	$95
Other	$596	$129	$53	$684	$218	$147
Total	$1,628	$394	$206	$1,901	$688	$537

Table 16 Annual costs (in 2050) and PV to 2050 (all $m) of different periphyton spatial exceedance criteria assumptions – marginal costs of EFW over the NPS-FM

Land use	Annual @ 10%	Annual @ 20%	Annual @ 30%	NPV @ 10%	PV @ 20%	PV @ 30%
Dairy	$157	$177	$204	$1,201	$1,413	$1,654
Sheep & Beef	$1	$1	$5	$2	$7	$40
Horticulture	$27	$27	$28	$203	$205	$217
Other	$88	$89	$94	$652	$700	$760
Total	$272	$294	$331	$2,058	$2,326	$2,671

The total costs are greater under the 10% assumption than 30% (Table 15) because of the greater requirement for discharge reduction, but the marginal additional costs of the EFW over the NPS-FM are greater for the 30% assumption (Table 16).

2.4.4 Sensitivity Analysis: DIN2.4

The assumption of DIN2.4 is a change to the assumed bottom line under the EFW. As for periphyton sensitivity, the detailed results are provided in Annex B. In Table 17 we show the estimated annual (2050) costs for the NPS-FM and EFW, and the differences in annual costs and the PV to 2050.

Assuming a less stringent DIN bottom line, results in a reduction in costs and the difference between costs under the NPS-FM and EFW.

Table 17 Annual costs (in 2050) ($m) of DIN2.4 for NPS-FM and the EFW, annual differences and PVs to 2050

Land use	NPS-FM	EFW DIN1.0	EFW DIN2.4	Annual Difference DIN1.0	Annual Difference DIN2.4	PV Difference DIN1.0	PV Difference DIN2.4
Dairy	$172	$349	$180	$177	$8	$1,413	$58
Sheep & Beef	$23	$24	$23	$1	$0	$7	$0
Horticulture	$70	$97	$78	$27	$7	$205	$53
Other	$129	$218	$143	$89	$15	$700	$107
Total	$394	$688	$424	$294	$30	$2,326	$218

2.4.5 Sensitivity Analysis: Technological Development

We test the impacts on costs of assuming an improvement in technical efficiency of on-farm mitigation, such that costs fall over time. We analyse annual cost reductions of 1% and 1.75%.

The impacts of reductions in costs on the costs of policy will depend on the pattern of implementation. We have escalated costs over time without being clear on the details, eg whether each farm will do a little more each year, if some farms will take actions early and others later. In theory, and assuming that there are few if any economies of scale assumed in the cost data, this should not matter, provided the pattern of escalation for an individual farm is to progressively take action on additional hectares, rather than taking more action on each hectare. For simplicity of analysis we assume that more hectares are addressed each year and that the best solution (on-farm mitigation or land use change) may change over time as relative prices change.

Relative prices change because we apply the cost improvements to on-farm mitigations but not to land use change, for which we assume no change in real profits.

The results at 1% per annum are shown in Table 18. They are directly comparable with Table 12. There is only a small difference in costs as a result, largely because of the significance of land use change to the total discharge reduction response, even with reduced on-farm mitigation costs.

Table 18 Annual and PV of costs to 2050 ($m) – technological change assumptions (1% pa improvement)

	Annual costs NPS-FM	Annual costs EFW	Annual costs - difference	PV NPS-FM	PV EFW	PV difference
Dairy	$168	$345	$177	$1,529	$2,939	$1,410
Sheep & Beef	$19	$20	$1	$171	$177	$5
Hort	$52	$72	$20	$475	$627	$152
Other	$115	$201	$86	$1,041	$1,719	$678
Total	$354	$638	$283	$3,216	$5,462	$2,246

Table 19 shows the results for a 1.75% per annum improvement. Costs are slightly lower but not significantly, again because of the extent of land use change.

Table 19 Annual and PV of costs to 2050 ($m) – technological change assumptions (1.75% pa improvement)

	Annual costs NPS-FM	Annual costs EFW	Annual costs - difference	PV NPS-FM	PV EFW	PV difference
Dairy	$166	$343	$177	$1,511	$2,919	$1,408
Sheep & Beef	$17	$17	$1	$150	$154	$4
Hort	$42	$58	$16	$380	$502	$122
Other	$107	$191	$84	$967	$1,633	$666
Total	$331	$609	$277	$3,009	$5,209	$2,200

3 Other Policies

3.1 Stock Exclusion

The requirements and costs of a new stock exclusion policy introduced as part of the EFW has been estimated by MfE and MPI. It will require an increase in the lengths of waterways that are currently fenced to exclude, eg those fenced already under the Dairy Accord.[31] The costs below are based on the following assumptions:

- Fencing associated with a 3 metre setback
- $5/m for fencing dairy farms and $14/m for fencing non-dairy
- opportunity costs of $2,238/ha for dairy farms and $520/ha for sheep and beef.

The estimated fencing requirements are shown in Table 20, alongside the estimated costs. Table 21 shows the estimated area of land that will be lost from production and estimates of the opportunity costs of that land. Table 21 also includes the total estimated costs, including fencing and land opportunity costs.

Table 20 Assumed fencing requirements and fencing costs

	Km fencing				Annualised costs ($ million)[1]			
Region	Dairy	Sheep and Beef	Deer	Total	Dairy	Sheep and Beef	Deer	Total
Northland	740	1,110	5	1,855	$0.4	$1.7	$0.0	$2.2
Auckland	213	275	5	493	$0.1	$0.4	$0.0	$0.6
Waikato	2,295	1,257	39	3,592	$1.3	$2.0	$0.1	$3.3
Bay of Plenty	275	293	22	589	$0.2	$0.5	$0.0	$0.7
Gisborne	1	153	1	155	$0.0	$0.2	$0.0	$0.2
Taranaki	1,122	353	4	1,479	$0.6	$0.6	$0.0	$1.2
MWT-WNG	639	2,561	41	3,241	$0.4	$4.0	$0.1	$4.4
Hawke's Bay	87	1,498	18	1,603	$0.0	$2.3	$0.0	$2.4
Wellington	118	822	4	944	$0.1	$1.3	$0.0	$1.4
Tas/Nelson	100	217	11	328	$0.1	$0.3	$0.0	$0.4
Marlborough	34	183	5	222	$0.0	$0.3	$0.0	$0.3
West Coast	229	454	22	706	$0.1	$0.7	$0.0	$0.9
Canterbury	585	5,111	321	6,016	$0.3	$8.0	$0.7	$9.0
Otago	451	4,826	54	5,332	$0.3	$7.5	$0.1	$7.9
Southland	602	4,753	205	5,560	$0.3	$7.4	$0.5	$8.2
Total	7,492	23,867	756	32,115	$4.2	$37.3	$1.7	$43.1

[1] Costs are amortised over 25 years at 3%
Source: MfE

[31] Dairy NZ (2015)

Table 21 Assumed land lost from production, opportunity costs and total costs including fencing

	Land lost to production (km²)				Opportunity costs ($m)				
	Dairy	Sheep and Beef	Deer	Total	Dairy	Sheep and Beef	Deer	Total	Total costs
Northland	4.4	6.7	0.0	11.1	$1.0	$0.3	$0.0	$1.3	$3.5
Auckland	1.3	1.7	0.0	3.0	$0.3	$0.1	$0.0	$0.4	$0.9
Waikato	13.8	7.5	0.2	21.6	$3.1	$0.4	$0.0	$3.5	$6.8
Bay of Plenty	1.6	1.8	0.1	3.5	$0.4	$0.1	$0.0	$0.5	$1.1
Gisborne	0.0	0.9	0.0	0.9	$0.0	$0.0	$0.0	$0.0	$0.3
Taranaki	6.7	2.1	0.0	8.9	$1.5	$0.1	$0.0	$1.6	$2.8
Manawatu-Wanganui	3.8	15.4	0.2	19.4	$0.9	$0.8	$0.0	$1.7	$6.1
Hawke's Bay	0.5	9.0	0.1	9.6	$0.1	$0.5	$0.0	$0.6	$3.0
Wellington	0.7	4.9	0.0	5.7	$0.2	$0.3	$0.0	$0.4	$1.8
Tasman	0.6	1.3	0.1	2.0	$0.1	$0.1	$0.0	$0.2	$0.6
Marlborough	0.2	1.1	0.0	1.3	$0.0	$0.1	$0.0	$0.1	$0.4
West Coast	1.4	2.7	0.1	4.2	$0.3	$0.1	$0.0	$0.5	$1.3
Canterbury	3.5	30.7	1.9	36.1	$0.8	$1.6	$0.1	$2.5	$11.5
Otago	2.7	29.0	0.3	32.0	$0.6	$1.5	$0.0	$2.1	$10.0
Southland	3.6	28.5	1.2	33.4	$0.8	$1.5	$0.1	$2.4	$10.6
Total	44.9	143.2	4.5	192.7	$10.1	$7.4	$0.2	$17.7	$60.9

Source: MfE

The PV of costs at 3%, using the profile of implementation as used for the EFW, is estimated at $522 million.

3.2 Sediment Bottom Lines

An analysis of the costs and benefits of sediment bottom lines was undertaken by Landcare Research,[32] building on physical modelling by NIWA.[33] The sediment policy was estimated to result in significant additional afforestation (an estimated 1.06 million ha - Table 22),[34] in addition to requirements for riparian exclusion (RE). Landcare estimate significant benefits from the additional carbon sequestration that results from the policy.

The annualised costs (see Figure 6) are estimated to sum to $316 million and the PV of costs, using the profile of implementation as used for the other policy elements, is estimated at $2,710 million. However, Landcare estimated net benefits from implementing the sediment bottom lines, taking account of the benefits of carbon credits. MfE suggests that there will be considerable overlap between the effects of the sediment policy and climate change policy, consistent with the Climate Change Response (Zero Carbon) Amendment Act 2019, such that neither the costs nor the benefits may be as modelled. We ignore the costs in this analysis.

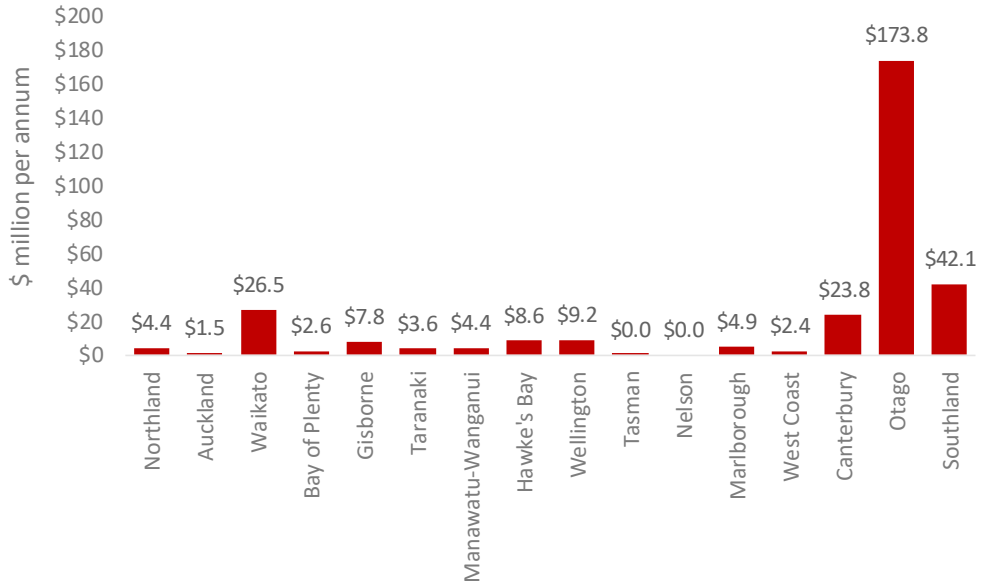
[32] Neverman *et al* (2019)
[33] Hicks *et al* (2019)
[34] According to MfE: "The afforestation figures and costs do not account for potential exemptions that may be applied. Exemptions are likely to have a particularly significant impact on the figures for Otago where the main catchments are glacial-fed."

Table 22 Land use and fencing impacts of sediment policy

	WFPs (000 ha)	Afforest-ation (000 ha)	Fencing (000 km)	Riparian planting (000 ha)	RE already in place (%)	Revised RE fencing (000 km)	Revised RE planting (000 ha)
Northland	0.0	22.3	10.1	5.1	71%	2.9	1.5
Auckland	0.0	2.3	1.3	0.7	64%	0.5	0.2
Waikato	1.1	123.3	55.1	27.5	80%	11.0	5.5
Bay of Plenty	0.4	9.4	13.5	6.8	83%	2.3	1.1
Gisborne	0.0	45.0	9.1	4.5	29%	6.4	3.2
Taranaki	0.7	1.3	2.4	1.2	77%	0.5	0.3
Manawatu-Wanganui	0.0	5.1	1.9	0.9	62%	0.7	0.4
Hawke's Bay	0.0	29.7	22.2	11.1	45%	12.2	6.1
Wellington	0.2	24.6	13.1	6.5	52%	6.3	3.1
Tasman	0.0	0.5	12.3	6.2	59%	5.1	2.5
Nelson	0.0	0.0	0.0	0.0	0%	0.0	0.0
Marlborough	0.0	25.3	11.5	5.8	34%	7.6	3.8
West Coast	0.0	1.5	39.3	19.6	65%	13.8	6.9
Canterbury	0.2	256.4	71.8	35.9	62%	27.3	13.6
Otago	0.5	428.5	54.6	27.3	48%	28.4	14.2
Southland	2.8	80.3	47.8	23.9	76%	11.5	5.7
Total	6.1	1,055.5	365.9	183.0	62%	11.5	69.0

Source: Neverman *et al* (2019)

Figure 6 Annualised costs of sediment policy



Source: Neverman *et al* (2019)

4 Summary and Conclusions

4.1 Modelling Approach

In this report we have described a model developed to analyse the costs of the proposed freshwater policies under the EFW package, relative to the costs that will result anyway from the NPS-FM.

The model used for analysis constructs cost curves for reducing discharges in each of 11,186 catchments. The cost curves comprise:

- The costs and effectiveness of mitigation bundles using assumptions provided by MfE. These are based on a combination of cost estimates from a study by Landcare Research, Motu and NIWA,[35] and estimates of mitigation bundle effectiveness assumptions from research by AgResearch.[36]

- The costs and effectiveness of land use change which uses differences in average profits as the basis for costs and differences in regional average discharge rates of N & P as the basis for effectiveness.

The model takes a relatively simplistic approach to land use change. It does not restrict land use change (apart from preventing land use change from dairy to forestry in Canterbury) to reflect any local circumstances or owner-specific preferences, but assumes changes will occur consistent with least cost discharge reduction.[37]

4.2 Summary of Results

The costs under the different assumptions are shown in Table 23. The base case results are shown in the first row. The change in periphyton spatial exceedance (PSEC) criteria (from 20% to 10% or 30%) has a small impact on the results; a more significant change is from the change to the DIN bottom line. Assumptions on technological change (which affect the future costs of mitigation options) have comparatively little impact on the PV of costs, largely because of the significance of land use change. Table 23 also shows the expected costs of the stock exclusion policy at different discount rates.

Table 24 summarises the modelled changes in land areas. The differences in land use change between the PSEC assumptions are more significant than the changes in costs, particularly under the 10% criterion. Changes in technology costs has no measurable difference on the extent of land use change.

[35] Daigneault *et al* (2016)
[36] Richard McDowell (personal communication); McDowall *et al* (in prep)
[37] A set of rules is used to govern land use change as described in Section 2.2.3

Table 23 Results Summary - 2050 Costs and PV of Costs to 2050 ($ million) of N & P bottom lines

			Annual costs			Present Value			
DIN	PSEC	Tech change	NPS-FM	EFW	Diffe-rence	PV @3%	PV @0%	PV@1%	PV@6%
1.0	20%	Static	$394	$688	$294	$2,326	$4,296	$3,481	$1,326
1.0	10%	Static	$1,628	$1,901	$272	$2,058	$3,855	$3,110	$1,153
1.0	30%	Static	$206	$537	$331	$2,671	$4,904	$3,981	$1,534
2.4	10%	Static	$1,628	$1,657	$28	$167	$325	$259	$90
2.4	20%	Static	$394	$424	$30	$218	$411	$331	$121
2.4	30%	Static	$206	$227	$21	$150	$283	$228	$84
1.0	20%	1%	$354	$638	$283	$2,246	$4,145	$3,360	$1,281
1.0	20%	1.75%	$331	$609	$277	$2,200	$4,060	$3,290	$1,256
Stock exclusion policy						$522	$938	$766	$309

PSEC = Periphyton Spatial Exceedance Criteria

Table 24 Results Summary – Change in land area

			Change in Dairy land Area			Change in Forestry Land Area		
DIN	PSEC	Tech change	NPS-FM	EFW	Difference	NPS-FM	EFW	Difference
1.0	20%	Static	-6.8%	-13.8%	-7.1%	3.9%	9.0%	5.2%
1.0	10%	Static	-35.6%	-42.0%	-6.4%	20.7%	25.3%	4.5%
1.0	30%	Static	-3.1%	-11.1%	-8.0%	1.0%	7.0%	6.0%
2.4	10%	Static	-35.6%	-35.9%	-0.3%	20.7%	20.8%	0.1%
2.4	20%	Static	-6.8%	-7.1%	-0.3%	3.9%	4.0%	0.1%
2.4	30%	Static	-3.1%	-3.4%	-0.3%	1.0%	1.1%	0.1%
1.0	20%	1%	-6.8%	-13.8%	-7.1%	3.9%	9.0%	5.2%
1.0	20%	1.75%	-6.8%	-13.8%	-7.1%	3.9%	9.0%	5.2%

PSC = Periphyton Spatial Exceedance Criteria

4.3 Regional Distribution

The highest estimated discharge reduction requirements (Table 1) and costs of implementing the EFW are in the Waikato and Canterbury regions; costs in these regions comprise 40% and 41% of total costs respectively, with Southland (6%) and Manawatu-Whanganui (4%) contributing an additional 10% of total costs. These regions also see the most significant estimated levels of land use change.

There are likely to be significant distributional differences across individual farms within all regions, but the modelling in this analysis has used average costs so these effects are not identified.

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6 Annex A: Land Use and Base Case Discharges

6.1 Land use by Region (km²)

Region	DAIRY	SBINTEN	SBHILL	SBHIGH	DEER	OTHER_ANIM	ARABLE	LIFESTYLE	OTHER_PASTURE	SCRUB_NAT_FOR	TUSSOCK	URBAN	PLANT_FOR	HORT	WATER	OTHER
Northland	1,713	2,730	400	0	7	4	0.0	475	510	3,849	0	79	1,842	94	56	213
Auckland	462	822	55	0	6	25	0.0	574	229	1,133	0	453	514	112	13	50
Waikato	5,932	1,488	3,599	40	66	63	1.4	753	1,017	6,455	82	268	3,277	193	818	377
Bay of Plenty	1,010	301	785	105	57	4	0.0	303	384	6,694	6	143	2,847	294	243	83
Gisborne	11	265	1,963	10	1	0	12.5	70	238	1,664	2	28	1,562	167	24	111
Taranaki	2,150	435	864	35	16	7	0.0	130	241	2,881	7	68	300	17	27	39
Manawatu-Wanganui	1,641	2,107	7,436	85	68	19	38.7	307	832	6,789	576	145	1,589	177	98	294
Hawke's Bay	284	2,243	4,112	151	37	1	0.0	144	527	4,988	232	83	1,862	345	127	116
Wellington	397	614	2,042	27	10	6	0.0	223	297	3,124	43	194	805	81	97	81
Tasman	185	188	75	165	17	1	0.0	176	135	3,484	261	24	952	93	19	91
Nelson	6	3	1	8	0	0	0.0	20	7	172	3	24	112	0	1	3
Marlborough	109	860	405	555	8	0	4.5	130	337	3,587	567	27	819	328	41	793
West Coast	871	194	256	129	26	1	0.0	98	423	19,119	2,301	32	527	0	334	2,670
Canterbury	2,522	5,159	3,592	883	296	44	502.3	789	1,850	6,522	4,291	320	1,544	2,484	215	3,910
Otago	1,369	5,737	7,752	1,405	140	9	38.9	404	2,081	4,929	10,796	147	1,718	257	1,382	5,404
Southland	2,026	4,105	1,808	557	201	19	6.8	175	810	13,673	4,149	72	978	71	844	1,751
NZ	20,688	27,250	35,146	4,155	958	201	605	4,771	9,918	89,062	23,317	2,107	21,248	4,716	4,338	15,987

Note: SBINTEN = intensive sheep & beef; SBHILL = hill country sheep & beef; SBHIGH = high country sheep & beef

Source: NIWA

6.2 Discharges – N yield (kg/ha)

Region	DAIRY	SBINTEN	SBHILL	SBHIGH	DEER	OTHER_ANIM	ARABLE	LIFESTYLE	OTHER_PASTURE	SCRUB_NAT_FOR	TUSSOCK	URBAN	PLANT_FOR	HORT	WATER	OTHER
Northland	27.0	16.2	16.3	0.3	16.9	19.1	0.0	18.9	17.0	4.9	0.0	8.0	4.9	0.0	3.1	0.4
Auckland	23.1	12.2	12.0	0.3	11.6	13.2	0.0	13.5	13.2	4.2	0.0	8.0	4.4	0.1	3.1	0.3
Waikato	33.0	15.8	19.1	0.3	13.4	16.9	8.1	17.6	18.1	3.9	0.3	8.0	3.6	64.0	3.1	0.4
Bay of Plenty	40.5	20.6	22.8	0.2	19.7	24.5	0.0	24.0	22.5	3.4	0.2	8.0	3.2	0.0	3.1	0.3
Gisborne	28.1	14.5	11.5	0.3	15.9	20.4	17.8	14.3	13.2	4.2	0.3	8.0	4.1	0.0	3.1	0.3
Taranaki	51.1	14.4	10.3	0.3	10.7	19.0	0.0	18.7	15.2	3.8	0.6	8.0	3.4	0.0	3.1	0.4
Manawatu-Wanganui	31.0	11.2	9.6	0.3	10.6	12.5	38.7	12.6	11.5	3.6	0.2	8.0	3.7	75.3	3.1	0.3
Hawke's Bay	31.3	11.1	11.3	0.2	11.8	12.1	5.3	12.2	12.0	3.3	0.2	8.0	3.4	40.9	3.1	0.3
Wellington	37.8	12.5	9.6	0.3	12.0	14.7	0.0	12.9	11.4	4.6	0.6	8.0	3.8	0.0	3.1	0.3
Tasman	33.7	9.2	10.4	0.3	10.4	9.1	0.0	9.8	10.5	5.2	0.5	8.0	3.2	0.0	3.1	0.4
Nelson	17.3	7.1	13.1	0.2	0.0	0.0	0.0	5.6	7.0	3.2	0.2	8.0	3.2	0.0	3.1	0.2
Marlborough	16.2	5.6	4.6	0.2	8.6	8.0	7.9	6.7	6.3	3.2	0.2	8.0	3.0	0.0	3.1	0.2
West Coast	61.6	25.2	14.9	0.2	16.4	11.8	0.0	18.0	19.0	7.2	0.7	8.0	5.2	0.0	3.1	0.8
Canterbury	30.7	8.9	6.0	0.2	8.9	9.5	8.4	9.4	8.7	6.8	0.3	8.0	3.3	40.5	3.1	0.3
Otago	18.3	7.7	5.3	0.2	6.8	8.6	3.5	7.2	7.8	3.9	0.2	8.0	3.7	7.0	3.1	0.4
Southland	30.6	11.4	8.6	0.3	10.1	12.1	0.0	13.4	11.2	8.2	0.6	8.0	3.8	0.0	3.1	0.7
NZ (weighted ave)	34.1	11.0	9.9	0.2	10.4	13.7	10.1	13.9	11.9	5.5	0.4	8.0	3.7	30.2	3.1	0.5

Source: NIWA

6.3 Discharges – P yield (kg/ha)

Region	DAIRY	SBINTEN	SBHILL	SBHIGH	DEER	OTHER_ANIM	ARABLE	LIFESTYLE	OTHER_PASTURE	SCRUB_NAT_FOR	TUSSOCK	URBAN	PLANT_FOR	HORT	WATER	OTHER
Northland	2.53	1.83	2.22	0.32	1.44	1.05	0.00	1.42	1.48	0.27	0.00	0.80	0.26	0.26	0.20	0.24
Auckland	2.16	2.10	2.72	0.25	1.15	0.79	0.00	1.39	1.37	0.26	0.00	0.80	0.25	0.25	0.20	0.25
Waikato	1.44	0.98	1.34	0.30	0.74	0.39	0.24	0.70	0.95	0.33	0.47	0.80	0.28	0.26	0.20	0.35
Bay of Plenty	2.18	0.91	3.18	0.30	1.07	0.60	0.00	1.14	1.64	0.32	0.29	0.80	0.28	0.30	0.20	0.32
Gisborne	3.45	1.58	2.14	0.27	0.91	0.57	0.25	1.32	2.33	0.31	0.38	0.80	0.29	0.24	0.20	0.33
Taranaki	1.28	0.95	2.19	0.42	1.14	0.79	0.00	0.56	1.28	0.40	1.75	0.80	0.30	0.30	0.20	0.92
Manawatu-Wanganui	1.31	0.67	1.58	0.31	0.97	0.49	0.20	0.58	1.25	0.32	0.35	0.80	0.26	0.22	0.20	0.49
Hawke's Bay	1.89	0.72	1.76	0.26	1.01	0.41	0.18	0.72	1.48	0.28	0.28	0.80	0.26	0.20	0.20	0.25
Wellington	1.24	0.78	1.41	0.32	1.88	0.92	0.00	1.07	1.27	0.38	0.81	0.80	0.24	0.21	0.20	0.30
Tasman	3.17	1.31	3.95	0.33	1.63	1.48	0.00	1.18	1.83	0.73	1.00	0.80	0.27	0.25	0.20	0.76
Nelson	2.18	1.35	0.57	0.29	0.00	0.00	0.00	1.68	1.82	0.29	0.31	0.80	0.28	0.24	0.20	0.28
Marlborough	4.30	0.47	1.67	0.21	1.22	0.08	0.17	1.23	1.64	0.28	0.25	0.80	0.25	0.19	0.20	0.26
West Coast	4.30	1.81	2.40	0.32	2.33	2.93	0.00	2.33	3.33	1.56	2.76	0.80	0.60	0.88	0.20	4.83
Canterbury	0.46	0.10	0.38	0.23	0.11	0.07	0.18	0.10	0.42	0.29	0.32	0.80	0.20	0.18	0.20	0.47
Otago	0.48	0.21	0.28	0.20	0.15	0.24	0.16	0.23	0.57	0.34	0.26	0.80	0.19	0.17	0.20	0.91
Southland	0.81	0.42	0.82	0.21	0.55	0.26	0.20	0.34	1.03	1.24	1.45	0.80	0.22	0.21	0.20	1.78
NZ (weighted ave)	1.47	0.63	1.22	0.23	0.56	0.42	0.18	0.82	1.08	0.74	0.74	0.80	0.27	0.20	0.20	1.47

Source: NIWA

7 Annex B: Detailed Results

7.1 Base Case: NPS-FM

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$1.1	$0.4	$0.0	$1.2	$2.7	$0.7	$0.8	$1.2	-1.1%	0.0%	1.0%	0.0%
Auckland	$3.9	$1.0	$0.0	$1.3	$6.2	$0.5	$4.4	$1.3	-7.9%	-2.6%	11.4%	0.0%
Waikato	$31.2	$0.1	$0.0	$0.4	$31.7	$0.1	$31.2	$0.4	-4.1%	0.0%	7.4%	0.0%
Bay of Plenty	$1.2	$0.1	$0.0	$2.0	$3.3	$0.8	$0.6	$1.9	-0.5%	0.0%	0.2%	0.0%
Gisborne	$0.0	$0.5	$0.0	$0.7	$1.1	$0.5	$0.0	$0.7	0.0%	0.0%	0.0%	0.0%
Taranaki	$39.3	$0.0	$0.0	$5.1	$44.5	$0.1	$39.2	$5.1	-14.5%	0.0%	103.8%	0.0%
Manawatu-Wanganui	$20.8	$1.7	$0.3	$3.6	$26.4	$2.0	$20.7	$3.6	-10.7%	0.0%	11.1%	0.0%
Hawke's Bay	$0.2	$2.2	$3.0	$16.2	$21.5	$5.6	$0.0	$16.0	0.0%	0.0%	0.0%	0.0%
Wellington	$1.2	$0.4	$0.0	$1.1	$2.7	$0.4	$1.2	$1.1	-2.5%	0.0%	1.2%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	-0.2%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$48.8	$5.4	$67.2	$75.5	$197.0	$79.2	$45.5	$72.3	-16.0%	0.0%	0.0%	80.4%
Otago	$3.8	$3.2	$0.0	$0.3	$7.3	$6.8	$0.2	$0.3	-0.2%	0.0%	0.0%	5.8%
Southland	$20.2	$8.0	$0.0	$21.0	$49.3	$16.4	$13.5	$19.3	-9.6%	0.0%	0.0%	2837.9%
NZ	$171.9	$23.0	$70.5	$128.7	$394.1	$113.3	$157.4	$123.4	-6.8%	0.0%	3.9%	99.1%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$150	$22	$172	$1,561
Sheep & Beef	$17	$6	$23	$209
Hort	$70	$0	$70	$640
Other	$119	$10	$129	$1,169
Total	$355	$39	$394	$3,579

7.2 Base Case: EFW

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$1.4	$0.4	$0.0	$1.4	$3.2	$0.7	$1.1	$1.4	-1.4%	0.0%	1.3%	0.0%
Auckland	$6.9	$1.0	$0.0	$1.6	$9.6	$0.5	$7.4	$1.6	-14.1%	-2.7%	17.1%	0.0%
Waikato	$150.0	$0.1	$0.0	$0.5	$150.6	$0.1	$150.0	$0.5	-19.7%	0.0%	35.7%	0.0%
Bay of Plenty	$5.1	$0.1	$0.0	$2.3	$7.6	$0.8	$4.6	$2.2	-3.9%	0.0%	1.4%	0.0%
Gisborne	$0.0	$0.5	$0.0	$0.8	$1.2	$0.5	$0.0	$0.8	0.0%	0.0%	0.0%	0.0%
Taranaki	$42.0	$0.0	$0.0	$8.3	$50.2	$0.1	$41.8	$8.3	-15.5%	0.0%	110.8%	0.0%
Manawatu-Wanganui	$30.5	$1.7	$0.3	$4.3	$36.8	$2.0	$30.4	$4.3	-15.7%	0.0%	16.2%	0.0%
Hawke's Bay	$0.2	$2.2	$3.0	$23.4	$28.8	$5.6	$0.0	$23.2	0.0%	0.0%	0.0%	0.0%
Wellington	$1.2	$0.4	$0.0	$1.4	$3.0	$0.4	$1.2	$1.4	-2.5%	0.0%	1.2%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	-0.2%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$79.2	$5.5	$93.8	$140.3	$318.9	$107.0	$75.2	$136.6	-26.2%	0.1%	0.0%	130.0%
Otago	$5.7	$4.0	$0.0	$0.4	$10.1	$8.8	$0.9	$0.4	-1.0%	0.0%	0.0%	34.3%
Southland	$27.0	$8.0	$0.0	$32.6	$67.5	$16.4	$20.3	$30.9	-14.3%	0.0%	0.0%	4252.3%
NZ	$349.2	$24.1	$97.1	$217.7	$688.1	$143.2	$332.9	$211.9	-13.8%	0.0%	9.0%	158.2%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$327	$22	$349	$2,975
Sheep & Beef	$18	$6	$24	$217
Hort	$97	$0	$97	$845
Other	$206	$12	$218	$1,869
Total	$648	$40	$688	$5,905

7.3 Base Case: Difference

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.2	$0.0	$0.0	$0.3	$0.5	$0.0	$0.2	$0.3	-0.3%	0.0%	0.3%	0.0%
Auckland	$3.0	$0.0	$0.0	$0.3	$3.3	$0.0	$3.0	$0.3	-6.2%	-0.1%	5.8%	0.0%
Waikato	$118.8	$0.0	$0.0	$0.1	$118.9	$0.0	$118.8	$0.1	-15.6%	0.0%	28.2%	0.0%
Bay of Plenty	$3.9	$0.0	$0.0	$0.3	$4.2	$0.0	$3.9	$0.3	-3.4%	0.0%	1.2%	0.0%
Gisborne	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Taranaki	$2.7	$0.0	$0.0	$3.1	$5.8	$0.0	$2.7	$3.1	-1.0%	0.0%	7.1%	0.0%
Manawatu-Wanganui	$9.7	$0.0	$0.0	$0.7	$10.4	$0.0	$9.7	$0.7	-5.0%	0.0%	5.2%	0.0%
Hawke's Bay	$0.0	$0.0	$0.0	$7.2	$7.2	$0.0	$0.0	$7.2	0.0%	0.0%	0.0%	0.0%
Wellington	$0.0	$0.0	$0.0	$0.3	$0.3	$0.0	$0.0	$0.3	0.0%	0.0%	0.0%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Canterbury	$30.4	$0.1	$26.6	$64.8	$121.9	$27.9	$29.7	$64.3	-10.2%	0.1%	0.0%	49.7%
Otago	$1.9	$0.9	$0.0	$0.1	$2.8	$2.0	$0.8	$0.1	-0.8%	0.0%	0.0%	28.4%
Southland	$6.7	$0.0	$0.0	$11.6	$18.3	$0.0	$6.7	$11.6	-4.8%	0.0%	0.0%	1414.4%
NZ	$177.3	$1.1	$26.6	$89.0	$294.0	$29.9	$175.6	$88.5	-7.1%	0.0%	5.2%	59.0%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$177	$0	$177	$1,413
Sheep & Beef	$1	$0	$1	$7
Hort	$27	$0	$27	$205
Other	$87	$2	$89	$700
Total	$292	$2	$294	$2,326

7.4 Periphyton 10: NPS-FM

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$9.9	$2.5	$0.0	$21.7	$34.2	$3.8	$8.6	$21.7	-11.3%	0.0%	10.5%	0.0%
Auckland	$8.1	$2.6	$0.0	$6.4	$17.2	$0.9	$9.9	$6.4	-16.6%	-9.4%	29.5%	0.0%
Waikato	$136.0	$6.8	$0.1	$42.1	$185.0	$11.9	$131.1	$42.1	-17.2%	0.0%	31.2%	0.0%
Bay of Plenty	$20.3	$5.5	$0.0	$30.1	$55.9	$8.1	$17.9	$29.9	-15.5%	0.0%	5.5%	0.0%
Gisborne	$0.4	$13.1	$0.0	$41.3	$54.8	$13.2	$0.3	$41.3	-44.6%	0.0%	0.2%	14.5%
Taranaki	$149.6	$5.6	$0.0	$28.2	$183.5	$7.5	$147.7	$28.2	-54.6%	0.0%	391.4%	0.0%
Manawatu-Wanganui	$162.0	$33.8	$5.6	$99.8	$301.2	$44.1	$157.9	$99.1	-81.5%	0.0%	84.2%	0.0%
Hawke's Bay	$3.8	$19.5	$3.4	$63.3	$90.0	$23.9	$3.1	$63.1	-11.2%	0.0%	1.7%	0.0%
Wellington	$26.1	$8.5	$0.0	$25.2	$59.8	$9.5	$25.1	$25.2	-53.9%	0.0%	26.6%	0.0%
Tasman	$2.8	$0.5	$0.0	$0.1	$3.4	$0.5	$2.8	$0.1	-31.7%	0.0%	6.2%	0.0%
Nelson	$0.1	$0.1	$0.0	$0.7	$0.9	$0.1	$0.1	$0.7	-36.7%	0.0%	1.9%	0.0%
Marlborough	$3.1	$4.0	$0.0	$11.9	$19.0	$4.2	$2.9	$11.9	-29.7%	0.0%	3.9%	0.0%
West Coast	$1.4	$0.0	$0.0	$0.8	$2.3	$0.3	$1.2	$0.8	-2.9%	0.0%	4.8%	0.0%
Canterbury	$100.5	$10.7	$81.2	$100.0	$292.4	$100.1	$96.1	$96.2	-33.8%	0.0%	0.0%	169.3%
Otago	$58.5	$23.1	$0.0	$38.7	$120.2	$29.3	$53.6	$37.3	-56.2%	0.0%	0.0%	1979.2%
Southland	$105.6	$17.5	$0.0	$85.7	$208.8	$26.6	$98.5	$83.8	-69.7%	0.0%	0.0%	20664.5 %
NZ	$788.2	$153.8	$90.4	$596.2	$1,628.5	$284.0	$756.9	$587.6	-35.6%	-0.1%	20.7%	501.2%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$519	$269	$788	$7,159
Sheep & Beef	$34	$120	$154	$1,397
Hort	$90	$0	$90	$821
Other	$335	$261	$596	$5,415
Total	$979	$650	$1,628	$14,791

7.5 Periphyton 10: EFW

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$10.2	$2.5	$0.0	$23.0	$35.7	$3.8	$8.9	$23.0	-11.6%	0.0%	10.8%	0.0%
Auckland	$11.1	$2.7	$0.0	$6.9	$20.7	$0.9	$12.9	$6.9	-22.8%	-9.5%	35.3%	0.0%
Waikato	$249.2	$6.8	$0.1	$46.8	$303.0	$9.3	$247.0	$46.7	-32.4%	0.0%	58.7%	0.0%
Bay of Plenty	$20.7	$5.5	$0.0	$30.9	$57.1	$8.1	$18.3	$30.7	-15.8%	0.0%	5.6%	0.0%
Gisborne	$0.4	$13.1	$0.0	$43.2	$56.7	$13.2	$0.3	$43.2	-44.6%	0.0%	0.2%	14.5%
Taranaki	$152.2	$5.6	$0.0	$30.7	$188.6	$7.5	$150.4	$30.7	-55.6%	0.0%	398.4%	0.0%
Manawatu-Wanganui	$162.2	$33.8	$5.6	$104.6	$306.1	$44.1	$158.1	$103.9	-81.6%	0.0%	84.3%	0.0%
Hawke's Bay	$3.8	$19.5	$3.4	$69.2	$95.9	$23.9	$3.1	$68.9	-11.2%	0.0%	1.7%	0.0%
Wellington	$26.1	$8.5	$0.0	$26.3	$60.9	$9.5	$25.1	$26.3	-53.9%	0.0%	26.6%	0.0%
Tasman	$2.8	$0.5	$0.0	$0.1	$3.4	$0.6	$2.8	$0.1	-31.7%	0.0%	6.2%	0.0%
Nelson	$0.1	$0.1	$0.0	$0.7	$0.9	$0.1	$0.1	$0.7	-36.7%	0.0%	1.9%	0.0%
Marlborough	$3.1	$4.1	$0.0	$11.7	$18.9	$4.3	$2.9	$11.7	-29.7%	0.0%	3.9%	0.0%
West Coast	$1.4	$0.0	$0.0	$0.9	$2.4	$0.3	$1.2	$0.9	-2.9%	0.0%	4.8%	0.0%
Canterbury	$130.3	$10.7	$107.9	$146.3	$395.2	$127.4	$125.8	$142.0	-44.0%	0.1%	0.0%	219.0%
Otago	$59.2	$23.6	$0.0	$41.5	$124.2	$29.8	$54.4	$40.1	-57.0%	0.0%	0.0%	2007.6%
Southland	$112.3	$17.5	$0.0	$101.3	$231.1	$26.6	$105.2	$99.3	-74.4%	0.0%	0.0%	22078.9%
NZ	$945.4	$154.4	$117.0	$684.2	$1,901.0	$309.3	$916.6	$675.1	-42.0%	-0.1%	25.3%	560.2%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$679	$267	$945	$8,360
Sheep & Beef	$35	$120	$154	$1,398
Hort	$117	$0	$117	$1,024
Other	$420	$264	$684	$6,067
Total	$1,250	$651	$1,901	$16,849

7.6 Periphyton 10: Difference

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.2	$0.0	$0.0	$1.3	$1.5	$0.0	$0.2	$1.3	-0.3%	0.0%	0.3%	0.0%
Auckland	$3.0	$0.0	$0.0	$0.5	$3.5	$0.0	$3.0	$0.5	-6.2%	-0.1%	5.8%	0.0%
Waikato	$113.3	$0.0	$0.0	$4.7	$117.9	-$2.6	$115.9	$4.7	-15.2%	0.0%	27.6%	0.0%
Bay of Plenty	$0.4	$0.0	$0.0	$0.8	$1.2	$0.0	$0.4	$0.8	-0.4%	0.0%	0.1%	0.0%
Gisborne	$0.0	$0.0	$0.0	$1.9	$1.9	$0.0	$0.0	$1.9	0.0%	0.0%	0.0%	0.0%
Taranaki	$2.7	$0.0	$0.0	$2.5	$5.2	$0.0	$2.7	$2.5	-1.0%	0.0%	7.1%	0.0%
Manawatu-Wanganui	$0.2	$0.0	$0.0	$4.8	$4.9	$0.0	$0.2	$4.8	-0.1%	0.0%	0.1%	0.0%
Hawke's Bay	$0.0	$0.0	$0.0	$5.9	$5.9	$0.0	$0.0	$5.9	0.0%	0.0%	0.0%	0.0%
Wellington	$0.0	$0.0	$0.0	$1.1	$1.1	$0.0	$0.0	$1.1	0.0%	0.0%	0.0%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	-$0.2	-$0.1	$0.1	$0.0	-$0.2	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Canterbury	$29.9	$0.1	$26.6	$46.3	$102.9	$27.3	$29.7	$45.8	-10.2%	0.1%	0.0%	49.7%
Otago	$0.8	$0.5	$0.0	$2.7	$4.0	$0.5	$0.8	$2.7	-0.8%	0.0%	0.0%	28.4%
Southland	$6.7	$0.0	$0.0	$15.6	$22.3	$0.0	$6.7	$15.6	-4.8%	0.0%	0.0%	1414.4%
NZ	$157.2	$0.6	$26.6	$88.0	$272.5	$25.3	$159.7	$87.5	-6.4%	0.0%	4.5%	59.0%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$160	-$3	$157	$1,201
Sheep & Beef	$1	$0	$1	$2
Hort	$27	$0	$27	$203
Other	$84	$4	$88	$652
Total	$271	$1	$272	$2,058

7.7 Periphyton 30: NPS-FM

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.4	$0.1	$0.0	$0.2	$0.7	$0.1	$0.4	$0.2	-0.5%	0.0%	0.5%	0.0%
Auckland	$1.0	$0.2	$0.0	$0.1	$1.3	$0.2	$1.0	$0.1	-2.1%	0.0%	1.9%	0.0%
Waikato	$12.9	$0.0	$0.0	$0.0	$13.0	$0.2	$12.8	$0.0	-1.7%	0.0%	3.0%	0.0%
Bay of Plenty	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Gisborne	$0.0	$0.2	$0.0	$0.0	$0.2	$0.2	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Taranaki	$4.8	$0.0	$0.0	$0.0	$4.8	$0.0	$4.8	$0.0	-1.8%	0.0%	12.7%	0.0%
Manawatu-Wanganui	$6.8	$0.0	$0.3	$0.8	$7.8	$0.3	$6.7	$0.8	-3.5%	0.0%	3.6%	0.0%
Hawke's Bay	$0.0	$0.0	$2.8	$3.5	$6.3	$2.9	$0.0	$3.3	0.0%	0.0%	0.0%	0.0%
Wellington	$0.5	$0.1	$0.0	$0.0	$0.6	$0.1	$0.5	$0.0	-1.1%	0.0%	0.6%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$43.1	$4.9	$63.7	$48.2	$159.9	$75.2	$39.9	$44.8	-14.0%	0.0%	0.0%	70.5%
Otago	$2.5	$0.0	$0.0	$0.0	$2.6	$1.5	$1.0	$0.0	-1.1%	0.0%	0.0%	38.4%
Southland	$5.6	$2.8	$0.0	$0.0	$8.5	$4.9	$3.6	$0.0	-2.5%	0.0%	0.0%	745.3%
NZ	$77.8	$8.3	$66.8	$52.9	$205.8	$85.6	$70.8	$49.4	-3.1%	0.0%	1.0%	69.4%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$76	$2	$78	$707
Sheep & Beef	$8	$1	$8	$75
Hort	$67	$0	$67	$607
Other	$53	$0	$53	$480
Total	$203	$3	$206	$1,870

7.8 Periphyton 30: EFW

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.7	$0.1	$0.0	$0.2	$1.0	$0.1	$0.6	$0.2	-0.8%	0.0%	0.8%	0.0%
Auckland	$4.3	$0.2	$0.0	$0.2	$4.7	$0.2	$4.3	$0.2	-9.0%	-0.1%	8.3%	0.0%
Waikato	$132.3	$0.0	$0.0	$0.0	$132.3	$0.1	$132.3	$0.0	-17.4%	0.0%	31.4%	0.0%
Bay of Plenty	$4.0	$0.0	$0.0	$0.0	$4.0	$0.0	$4.0	$0.0	-3.4%	0.0%	1.2%	0.0%
Gisborne	$0.0	$0.2	$0.0	$0.0	$0.2	$0.2	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Taranaki	$15.6	$0.0	$0.0	$8.9	$24.5	$0.0	$15.6	$8.9	-5.8%	0.0%	41.4%	0.0%
Manawatu-Wanganui	$27.8	$0.0	$0.3	$1.0	$29.0	$0.3	$27.7	$1.0	-14.3%	0.0%	14.8%	0.0%
Hawke's Bay	$0.0	$0.0	$3.0	$20.2	$23.2	$3.2	$0.0	$20.0	0.0%	0.0%	0.0%	0.0%
Wellington	$1.0	$0.1	$0.0	$0.0	$1.1	$0.1	$1.0	$0.0	-2.2%	0.0%	1.1%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$74.9	$5.1	$91.7	$116.3	$288.0	$104.3	$71.0	$112.7	-24.8%	0.1%	0.0%	122.6%
Otago	$5.6	$0.4	$0.0	$0.0	$5.9	$4.1	$1.8	$0.0	-1.9%	0.0%	0.0%	66.8%
Southland	$15.4	$7.2	$0.0	$0.0	$22.6	$12.3	$10.3	$0.0	-7.3%	0.0%	0.0%	2159.7%
NZ	$281.6	$13.3	$94.9	$147.1	$537.0	$125.0	$268.7	$143.3	-11.1%	0.0%	7.0%	130.5%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$280	$2	$282	$2,361
Sheep & Beef	$13	$1	$13	$115
Hort	$95	$0	$95	$824
Other	$147	$0	$147	$1,240
Total	$534	$3	$537	$4,541

7.9 Periphyton 30: Difference

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.2	$0.0	$0.0	$0.1	$0.3	$0.0	$0.2	$0.1	-0.3%	0.0%	0.3%	0.0%
Auckland	$3.3	$0.0	$0.0	$0.1	$3.4	$0.0	$3.3	$0.1	-6.8%	-0.1%	6.3%	0.0%
Waikato	$119.3	$0.0	$0.0	$0.0	$119.3	-$0.1	$119.5	$0.0	-15.7%	0.0%	28.4%	0.0%
Bay of Plenty	$3.9	$0.0	$0.0	$0.0	$3.9	$0.0	$3.9	$0.0	-3.4%	0.0%	1.2%	0.0%
Gisborne	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Taranaki	$10.8	$0.0	$0.0	$8.9	$19.7	$0.0	$10.8	$8.9	-4.0%	0.0%	28.7%	0.0%
Manawatu-Wanganui	$21.0	$0.0	$0.0	$0.2	$21.2	$0.0	$21.0	$0.2	-10.8%	0.0%	11.2%	0.0%
Hawke's Bay	$0.0	$0.0	$0.2	$16.7	$16.9	$0.2	$0.0	$16.7	0.0%	0.0%	0.0%	0.0%
Wellington	$0.5	$0.0	$0.0	$0.0	$0.5	$0.0	$0.5	$0.0	-1.1%	0.0%	0.5%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Canterbury	$31.8	$0.2	$28.0	$68.1	$128.1	$29.1	$31.1	$67.8	-10.7%	0.1%	0.0%	52.1%
Otago	$3.0	$0.4	$0.0	$0.0	$3.4	$2.6	$0.8	$0.0	-0.8%	0.0%	0.0%	28.4%
Southland	$9.8	$4.4	$0.0	$0.0	$14.1	$7.4	$6.7	$0.0	-4.8%	0.0%	0.0%	1414.4%
NZ	$203.7	$5.0	$28.1	$94.2	$331.2	$39.4	$197.9	$93.9	-8.0%	0.0%	6.0%	61.1%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$204	$0	$204	$1,654
Sheep & Beef	$5	$0	$5	$40
Hort	$28	$0	$28	$217
Other	$94	$0	$94	$760
Total	$331	$0	$331	$2,671

7.10 DIN 2.4: NPS-FM

	Annual Costs								% Change in land use			
EFW	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$1.1	$0.4	$0.0	$1.2	$2.7	$0.7	$0.8	$1.2	-1.1%	0.0%	1.0%	0.0%
Auckland	$3.9	$1.0	$0.0	$1.3	$6.2	$0.5	$4.4	$1.3	-7.9%	-2.6%	11.4%	0.0%
Waikato	$31.2	$0.1	$0.0	$0.4	$31.7	$0.1	$31.2	$0.4	-4.1%	0.0%	7.4%	0.0%
Bay of Plenty	$1.2	$0.1	$0.0	$2.0	$3.3	$0.8	$0.6	$1.9	-0.5%	0.0%	0.2%	0.0%
Gisborne	$0.0	$0.5	$0.0	$0.7	$1.1	$0.5	$0.0	$0.7	0.0%	0.0%	0.0%	0.0%
Taranaki	$39.3	$0.0	$0.0	$5.1	$44.5	$0.1	$39.2	$5.1	-14.5%	0.0%	103.8%	0.0%
Manawatu-Wanganui	$20.8	$1.7	$0.3	$3.6	$26.4	$2.0	$20.7	$3.6	-10.7%	0.0%	11.1%	0.0%
Hawke's Bay	$0.2	$2.2	$3.0	$16.2	$21.5	$5.6	$0.0	$16.0	0.0%	0.0%	0.0%	0.0%
Wellington	$1.2	$0.4	$0.0	$1.1	$2.7	$0.4	$1.2	$1.1	-2.5%	0.0%	1.2%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	-0.2%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$48.8	$5.4	$67.2	$75.5	$197.0	$79.2	$45.5	$72.3	-16.0%	0.0%	0.0%	80.4%
Otago	$3.8	$3.2	$0.0	$0.3	$7.3	$6.8	$0.2	$0.3	-0.2%	0.0%	0.0%	5.8%
Southland	$20.2	$8.0	$0.0	$21.0	$49.3	$16.4	$13.5	$19.3	-9.6%	0.0%	0.0%	2837.9%
NZ	$171.9	$23.0	$70.5	$128.7	$394.1	$113.3	$157.4	$123.4	-6.8%	0.0%	3.9%	99.1%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$150	$22	$172	$1,561
Sheep & Beef	$17	$6	$23	$209
Hort	$70	$0	$70	$640
Other	$119	$10	$129	$1,169
Total	$355	$39	$394	$3,579

7.11 DIN 2.4: EFW

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$1.1	$0.4	$0.0	$1.2	$2.7	$0.7	$0.8	$1.2	-1.1%	0.0%	1.0%	0.0%
Auckland	$4.0	$1.0	$0.0	$1.4	$6.3	$0.5	$4.4	$1.3	-7.9%	-2.6%	11.5%	0.0%
Waikato	$34.2	$0.1	$0.0	$0.4	$34.7	$0.1	$34.2	$0.4	-4.5%	0.0%	8.1%	0.0%
Bay of Plenty	$1.2	$0.1	$0.0	$2.0	$3.3	$0.8	$0.6	$1.9	-0.5%	0.0%	0.2%	0.0%
Gisborne	$0.0	$0.5	$0.0	$0.7	$1.1	$0.5	$0.0	$0.7	0.0%	0.0%	0.0%	0.0%
Taranaki	$39.3	$0.0	$0.0	$5.2	$44.5	$0.1	$39.2	$5.2	-14.5%	0.0%	103.8%	0.0%
Manawatu-Wanganui	$20.8	$1.7	$0.3	$3.6	$26.4	$2.0	$20.7	$3.6	-10.7%	0.0%	11.1%	0.0%
Hawke's Bay	$0.2	$2.2	$3.0	$16.4	$21.8	$5.6	$0.0	$16.3	0.0%	0.0%	0.0%	0.0%
Wellington	$1.2	$0.4	$0.0	$1.1	$2.7	$0.4	$1.2	$1.1	-2.5%	0.0%	1.2%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	-0.2%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$53.6	$5.4	$74.6	$88.8	$222.3	$87.0	$50.2	$85.2	-17.7%	0.0%	0.0%	88.8%
Otago	$4.3	$3.2	$0.0	$0.3	$7.9	$7.4	$0.2	$0.3	-0.2%	0.0%	0.0%	5.8%
Southland	$20.2	$8.0	$0.0	$21.9	$50.1	$16.4	$13.5	$20.2	-9.6%	0.0%	0.0%	2837.9%
NZ	$180.2	$23.0	$77.8	$143.3	$424.4	$121.6	$165.1	$137.6	-7.1%	0.0%	4.0%	106.1%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$158	$22	$180	$1,619
Sheep & Beef	$17	$6	$23	$209
Hort	$78	$0	$78	$693
Other	$133	$10	$143	$1,275
Total	$386	$39	$424	$3,797

7.12 DIN 2.4: Difference

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Auckland	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	-0.1%	-0.1%	0.2%	0.0%
Waikato	$3.0	$0.0	$0.0	$0.0	$3.0	$0.0	$3.0	$0.0	-0.4%	0.0%	0.7%	0.0%
Bay of Plenty	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Gisborne	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Taranaki	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Manawatu-Wanganui	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Hawke's Bay	$0.0	$0.0	$0.0	$0.3	$0.3	$0.0	$0.0	$0.3	0.0%	0.0%	0.0%	0.0%
Wellington	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Canterbury	$4.8	$0.0	$7.4	$13.2	$25.4	$7.8	$4.8	$12.8	-1.7%	0.0%	0.0%	8.4%
Otago	$0.5	$0.0	$0.0	$0.0	$0.5	$0.5	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Southland	$0.0	$0.0	$0.0	$0.9	$0.9	$0.0	$0.0	$0.9	0.0%	0.0%	0.0%	0.0%
NZ	$8.3	$0.0	$7.4	$14.6	$30.3	$8.3	$7.8	$14.2	-0.3%	0.0%	0.1%	7.0%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$8	$0	$8	$58
Sheep & Beef	$0	$0	$0	$0
Hort	$7	$0	$7	$53
Other	$14	$0	$15	$107
Total	$30	$0	$30	$218

7.13 Tech Change 1%: NPS-FM

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$1.1	$0.4	$0.0	$1.1	$2.7	$0.7	$0.8	$1.1	-1.1%	0.0%	1.0%	0.0%
Auckland	$3.9	$1.0	$0.0	$1.3	$6.2	$0.5	$4.4	$1.2	-7.9%	-2.6%	11.4%	0.0%
Waikato	$31.2	$0.1	$0.0	$0.4	$31.7	$0.1	$31.2	$0.4	-4.1%	0.0%	7.4%	0.0%
Bay of Plenty	$1.2	$0.1	$0.0	$2.0	$3.3	$0.7	$0.6	$1.9	-0.5%	0.0%	0.2%	0.0%
Gisborne	$0.0	$0.5	$0.0	$0.6	$1.1	$0.5	$0.0	$0.6	0.0%	0.0%	0.0%	0.0%
Taranaki	$39.3	$0.0	$0.0	$4.6	$43.9	$0.1	$39.2	$4.6	-14.5%	0.0%	103.8%	0.0%
Manawatu-Wanganui	$20.8	$1.7	$0.2	$3.5	$26.2	$2.0	$20.7	$3.5	-10.7%	0.0%	11.1%	0.0%
Hawke's Bay	$0.2	$2.2	$2.2	$14.6	$19.2	$4.7	$0.0	$14.5	0.0%	0.0%	0.0%	0.0%
Wellington	$1.2	$0.4	$0.0	$1.0	$2.6	$0.4	$1.2	$1.0	-2.5%	0.0%	1.2%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	-0.2%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.0	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$48.0	$4.1	$49.9	$66.6	$168.6	$58.9	$45.5	$64.2	-16.0%	0.0%	0.0%	80.4%
Otago	$2.9	$2.4	$0.0	$0.3	$5.6	$5.1	$0.2	$0.3	-0.2%	0.0%	0.0%	5.8%
Southland	$18.5	$5.9	$0.0	$18.4	$42.8	$12.2	$13.5	$17.1	-9.6%	0.0%	0.0%	2837.9%
NZ	$168.4	$18.9	$52.3	$114.6	$354.1	$86.1	$157.4	$110.7	-6.8%	0.0%	3.9%	99.1%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$146	$22	$168	$1,529
Sheep & Beef	$13	$6	$19	$171
Hort	$52	$0	$52	$475
Other	$105	$10	$115	$1,041
Total	$316	$39	$354	$3,216

7.14 Tech Change 1%: EFW

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$1.4	$0.4	$0.0	$1.4	$3.2	$0.7	$1.1	$1.4	-1.4%	0.0%	1.3%	0.0%
Auckland	$6.9	$1.0	$0.0	$1.6	$9.5	$0.5	$7.4	$1.5	-14.1%	-2.7%	17.1%	0.0%
Waikato	$150.0	$0.1	$0.0	$0.5	$150.6	$0.1	$150.0	$0.5	-19.7%	0.0%	35.7%	0.0%
Bay of Plenty	$5.1	$0.1	$0.0	$2.3	$7.5	$0.7	$4.6	$2.2	-3.9%	0.0%	1.4%	0.0%
Gisborne	$0.0	$0.5	$0.0	$0.8	$1.2	$0.5	$0.0	$0.8	0.0%	0.0%	0.0%	0.0%
Taranaki	$42.0	$0.0	$0.0	$7.6	$49.6	$0.1	$41.8	$7.6	-15.5%	0.0%	110.8%	0.0%
Manawatu-Wanganui	$30.5	$1.7	$0.2	$4.2	$36.6	$2.0	$30.4	$4.2	-15.7%	0.0%	16.2%	0.0%
Hawke's Bay	$0.2	$2.2	$2.2	$21.8	$26.4	$4.7	$0.0	$21.6	0.0%	0.0%	0.0%	0.0%
Wellington	$1.2	$0.4	$0.0	$1.3	$2.9	$0.4	$1.2	$1.3	-2.5%	0.0%	1.2%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	-0.2%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	$0.1	$0.2	$0.1	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
West Coast	$0.1	$0.0	$0.0	$0.1	$0.2	$0.0	$0.0	$0.1	-0.1%	0.0%	0.1%	0.0%
Canterbury	$78.2	$4.2	$69.6	$128.7	$280.7	$79.5	$75.2	$126.0	-26.2%	0.1%	0.0%	130.0%
Otago	$4.5	$3.0	$0.0	$0.4	$7.9	$6.5	$0.9	$0.4	-1.0%	0.0%	0.0%	34.3%
Southland	$25.2	$5.9	$0.0	$29.7	$60.9	$12.2	$20.3	$28.4	-14.3%	0.0%	0.0%	4252.3%
NZ	$345.2	$19.7	$72.0	$200.6	$637.5	$108.3	$332.9	$196.3	-13.8%	0.0%	9.0%	158.2%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$323	$22	$345	$2,939
Sheep & Beef	$13	$6	$20	$177
Hort	$72	$0	$72	$627
Other	$189	$12	$201	$1,719
Total	$597	$40	$638	$5,462

7.15 Tech Change 1%: Difference

	Annual Costs								% Change in land use			
	Dairy	Sheep & beef	Horti-culture	Other	Total	Mitigation	Land use change	Other	Dairy	Sheep & beef	Forestry	Arable
Northland	$0.2	$0.0	$0.0	$0.3	$0.5	$0.0	$0.2	$0.3	-0.3%	0.0%	0.3%	0.0%
Auckland	$3.0	$0.0	$0.0	$0.3	$3.3	$0.0	$3.0	$0.3	-6.2%	-0.1%	5.8%	0.0%
Waikato	$118.8	$0.0	$0.0	$0.1	$118.9	$0.0	$118.8	$0.1	-15.6%	0.0%	28.2%	0.0%
Bay of Plenty	$3.9	$0.0	$0.0	$0.3	$4.2	$0.0	$3.9	$0.3	-3.4%	0.0%	1.2%	0.0%
Gisborne	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Taranaki	$2.7	$0.0	$0.0	$3.1	$5.7	$0.0	$2.7	$3.1	-1.0%	0.0%	7.1%	0.0%
Manawatu-Wanganui	$9.7	$0.0	$0.0	$0.7	$10.4	$0.0	$9.7	$0.7	-5.0%	0.0%	5.2%	0.0%
Hawke's Bay	$0.0	$0.0	$0.0	$7.1	$7.1	$0.0	$0.0	$7.1	0.0%	0.0%	0.0%	0.0%
Wellington	$0.0	$0.0	$0.0	$0.3	$0.3	$0.0	$0.0	$0.3	0.0%	0.0%	0.0%	0.0%
Tasman	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	$0.1	0.0%	0.0%	0.0%	0.0%
Nelson	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Marlborough	$0.0	$0.1	$0.0	$0.0	$0.1	$0.1	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
West Coast	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	0.0%	0.0%	0.0%	0.0%
Canterbury	$30.2	$0.1	$19.8	$62.1	$112.2	$20.7	$29.7	$61.8	-10.2%	0.1%	0.0%	49.7%
Otago	$1.6	$0.6	$0.0	$0.1	$2.3	$1.5	$0.8	$0.1	-0.8%	0.0%	0.0%	28.4%
Southland	$6.7	$0.0	$0.0	$11.3	$18.1	$0.0	$6.7	$11.3	-4.8%	0.0%	0.0%	1414.4%
NZ	$176.9	$0.8	$19.8	$86.0	$283.4	$22.2	$175.6	$85.6	-7.1%	0.0%	5.2%	59.0%

Costs ($ million)	Annual N	Annual P	Annual total	NPV
Dairy	$177	$0	$177	$1,410
Sheep & Beef	$1	$0	$1	$5
Hort	$20	$0	$20	$152
Other	$84	$2	$86	$678
Total	$282	$2	$283	$2,246