"Achieving Outcomes by Building Capability"

The AgriBusiness Group™

Overseer nutrient modelling of commercial vegetable production.

Prepared for Environment Canterbury

Prepared by The AgriBusiness Group

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Executive Summary

Background

Environment Canterbury (ECan) have requested that The AgriBusiness Group (TAG) provide advice on the application of Overseer nutrient modelling for commercial vegetable growing operations in Canterbury.

A common aspect of commercial vegetable operations is complicated rotational operations and some of the land utilised being held in both short term and long term lease hold agreements. The Canterbury Land and Water Regional Plan (LWRP) assigns nitrogen loss rates to land, resulting in commercial vegetable producers finding it difficult to access land with sufficient nitrogen allocation. This is mainly because the majority of land taken up in lease hold agreements has a nutrient allocation which is lower than the nutrients leached (predominantly N) under vegetable production.

The objective of this work was to calculate the total amount of nitrogen leached in each nutrient allocation zone by commercial vegetable growing operations across Canterbury.

Methodolgy

This report details the methodology used for the following tasks:

- Analyse existing Overseer files of a range of commercial vegetable growing properties in Canterbury.

- Create representative crop rotation scenarios which depict a range of standard rotations used in Canterbury in the commercial vegetable production sector in Overseer based on representative files and the Matrix of Good Management (MGM) files, which were developed by ECan, to represent the range of Overseer files found throughout Canterbury.

- Alter these scenarios to account for various soil and climatic effects within the Canterbury region.

- Calculate the current nitrogen losses for commercial vegetable operations for each LWRP sub-region catchment in Canterbury.

Results

- Although the methodology used to gain the total nitrogen leaching in the individual NAZ's required a degree of estimation as to the allocation of the areas by soil type and climate zone the authors believe that the methodology used to make those estimations means that the results are sufficiently robust to be used in decision making.

- Three of the LWRP sub-regional catchments have total nitrogen leaching results which exceed 20 tons per year. They are Ashburton (236 t), Selwyn (153 t) and the OTOP sub-region (64 t).

- These three sub-regional catchments account for 86 % of the total nitrogen leaching results for the Canterbury region with Ashburton being the highest with 45%, Selwyn the next at 29% and OTOP next at 12%.

- The two factors of soil type and climate have a big influence on the amount of nitrogen leached by any crop or rotation in any location.

- The Christchurch-West Melton sub-regional zone has the highest average nitrogen leaching at 61 kg N / ha / year. There is significant variation between the locations in terms of the average nitrogen leaching results which is dependent on the soil type and climatic factors and also what the rotation mix is in each sub-region.

- For the three highest total nitrogen leaching sub-regional catchments the average nitrogen leaching results vary from 50 kg N / ha / year in Ashburton to 42 kg N / ha / year in Selwyn to 39 kg N / ha / year in OTOP.

1 Introduction

Environment Canterbury (ECan) have requested that The AgriBusiness Group (TAG) provide advice on the application of Overseer[1] nutrient modelling for commercial vegetable growing operations in Canterbury.

The objective of this work was to:

Calculate the total amount of nitrogen leached in each nutrient allocation zone by commercial vegetable growing operations across Canterbury.

A common aspect of commercial vegetable operations is complicated rotational operations and some land utilised being held in both short term and long term lease hold agreements. The Canterbury Land and Water Regional Plan (LWRP) assigns nitrogen loss rates to land, resulting in commercial vegetable producers finding it difficult to access land with sufficient nitrogen allocation. This is mainly because the majority of land taken up in lease hold agreements has a nutrient allocation which is lower than the nutrients leached (predominantly N) under vegetable production. Therefore they find it difficult to access sufficient lease land which also has sufficient nutrient allocation which would allow them to grow the full range of crops required.

This report covers the methodology used and the results of the following tasks:

- Analyse existing Overseer files of a range of commercial vegetable growing properties in Canterbury. It was envisaged that those files would be contributed by the members of a working group which ECan called together for this project and some nine properties which HortNZ used to estimate the range of leaching of N in Canterbury.

- Create representative crop rotation scenarios which depict a range of standard rotations used in Canterbury in the commercial vegetable production sector in Overseer based on representative files and the Matrix of Good Management (MGM) files which were developed by ECan to represent the range of Overseer files found throughout Canterbury.

- Alter these scenarios to account for various soil and climatic effects within the Canterbury region.

[1] A farm is a complex living system; made up of soil, plants, water and often animals – which all contain nutrients. The dynamic nature of a farm adds to the complexity of modelling nutrient flows, because different farming practices and preferences affect how nutrients cycle around the farm. To create a farm analysis, Overseer captures information about how a farm is run and models it through a series of complex sub-models that mimic the known bio-physical processes operating across a farm system. This allows Overseer to analyse the flow of nutrients through the farm and produce nutrient budgets for seven key farm nutrients and greenhouse gas footprint reports. The seven major farm nutrients include nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg) and sodium (Na) – as well as acidity for pastoral blocks.

There is a full technical description of how Overseer works at: www.overseer.org.nz

- Calculate the current nitrogen losses for commercial vegetable operations for each LWRP sub-region catchment in Canterbury.

2 Analysis of Overseer files of commercial vegetable growers

2.1 Methodology

The methodology used to determine the total volume of N leaching in each NAZ consisted of first constructing three crop rotation[2] scenarios in Overseer Version 6.3.0 by reference to a wide range of Overseer inputs. These crop rotations have been developed from a number of sources including industry knowledge of the Horticultural sector and the considerable amount of work which went into the MGM project which identified 10 different farming types which were representative of farming systems across Canterbury. Although there is no statistical justification for their selection we are very confident that they are a fair representation of the types of system in place in Canterbury that can be used in this level of analysis.

2.2 The Process of the Analysis

Members of a horticultural operations working group (set up by ECan) were asked to supply their existing Overseer files. The response from the working group was not sufficient for us to establish the range of operations across the commercial vegetable growing sector in Canterbury. This was partially because most of the growers did not have Overseer files for their properties.

HortNZ then supplied TAG with a complete list of their Canterbury members which also listed the main crops which they grew. TAG went through this list and identified approximately twenty growers based on their knowledge of the growers' operations that represented the major commercial vegetable rotations (Root crops, Green vegetables and Market Garden), and also represented the range of soil drainage types, climatic conditions and geographical locations in Canterbury.

These twenty people were contacted and we requested that they share their Overseer files with us. We received nine Overseer files from four of these growers. A number of the growers that are involved in the commercial vegetable growing sector have multiple properties which all require individual Overseer files to be calculated on them.

HortNZ carried out a survey of nine Horticultural growers in 2015 and as part of that survey sufficient information on the nature and detail of their commercial vegetable growing was gathered to carry out Overseer modeling on them. This modeling was carried out by Plant and Food and TAG have the .xml files from that exercise. This data was also included in this analysis.

The following data was extracted from the nineteen Overseer files which we had access to for every crop that was grown. This data was the information which is required to be able to model the rotation in Overseer which is basically the individual crop management including such things as crop timing, fertiliser inputs and irrigation management:

- Crop rotation
- Crop type
- Sowing date

[2] A crop rotation is a description of the full range of crops which are grown in a rotation over the life of the rotation.

- Cultivation method
- Harvest date
- Yield (tonnes per hectare)
- Residual treatment[3]
- Fertiliser type, rate of application, date of application and the Nitrogen (N), Phosphorus (P) and Potassium (K) and content of each application.
- Irrigation type, amount, return period, trigger level when irrigation is started and target which represents the target level of soil moisture holding capacity which the irrigation system is designed to meet for each month of the irrigation season.

2.3 Results of the data gathering from the Overseer files.

Data which was extracted from the Overseer files was collected on the following commercial vegetable crops, the restorative[4] crops which are part of the rotation, and the crops[5] which are grown during the winter to avoid N leaching:

- Annual ryegrass
- Beans
- Cabbage
- Broccoli
- Cauliflower
- Carrots
- Forage Oats
- Onions
- Peas
- Potato
- Pumpkin
- Spinach
- Squash
- Sweet corn.

For some of these crops such as the market garden crops only one example was received. For other crops there were multiple examples which represented the range of alternative sowing dates and yields that are used by commercial vegetable growers across Canterbury as many of the crops are sown at different times of the year, their management and inputs and the ultimate yields are different according to when they are sown. TAG is comfortable that the range of information gained from the Overseer files received was sufficient to carry out the modelling and analysis required to fairly represent the range of alternative grower examples.

[3] Residual treatment refers to the manner in which the residual material which is left in a paddock after the crop is harvested is treated. Options include working it back into the soil, grazing or bailing it and removal.
[4] Restorative crops are crops which restore the texture and the fertility of the soil. They include white clover and ryegrass seed crops.
[5] Crops which are grown during the winter in order to avoid N leaching include lupins,oats and short term ryegrass.

2.3.1 Fertiliser Inputs Gathered

This data was then analysed to get the average fertiliser inputs (kg/ha) for each crop. These are shown in Table 1. In Table 1 the first column lists the crop grown, the second column represents the month that the fertiliser is applied, the next column "fertiliser type" reports the brand name of the fertiliser, the next column represents the rate that the fertiliser is applied at and the next four columns report the kilograms of each element (N = Nitrogen, P = Phosphorus, K = Potassium and S = Sulphur) applied per application.

Table 1. Average fertiliser inputs for individual crops.

Crop	Month ***	Fertiliser type	Rate (kg/ha)	N (kg)	P (kg)	K (kg)	S (kg)
Broccoli	Mar	Potash Gold	375	26	58	47	23
	May	CAN*	150	40	-	-	-
	Aug	Urea	175	80	-	-	-
Peas	Sept/Oct	DAP **	100	18	20	-	1
		Muriate of Potash	100	-	-	50	-
Squash	Oct	YaraMila	350	43	18	15	28
	Dec	Urea	80	37			
Onions	Jun	DAP	200	35	40	-	2
	Jun	Sulphur Gain	30	-	-	-	27
	Sep	YaraMila Complex	375	46	20	56	30
	Oct	DAP	125	22	25	-	1
	Dec	YaraMila Complex	90	11	5	14	7
Cauliflower	Jan	YaraMila Complex	375	46	20	56	30
	Feb	YaraMila Complex	150	19	8	22	12
	Mar	YaraMila Complex	150	19	8	22	12
	Apr	YaraMila Complex	150	19	8	22	12
Potato	Oct	DAP	350	62	70	-	4
	Oct	Kieserite	75	-	-	-	12
	Nov	DAP	140	25	28	-	1
	Nov	Kieserite	60	-	-	-	10
	Nov	Muriate of Potash	80	-	-	40	-
	Dec	Urea	200	92	-	-	-
Carrots	Oct	YaraMila Comple	250	31	13	38	20
	Dec	CAN	125	34	-	-	-
Spinach	Jan + Apr	Cropmaster Brassica	550	78	88	55	4
	Jan + Apr	Kieserite	100	-	-	-	20
Cabbage	Sep	Cropmaster Brassica	550	78	88	55	4
	Oct	YaraMila Complex	150	19	8	22	12
	Nov	YaraMila Complex	150	19	8	22	12
	Dec	YaraMila Complex	150	19	8	22	12
Sweetcorn	Oct	Cropmaster Brassica	550	78	88	55	4
	Oct	Urea	50	23	-	-	-
	Dec	YaraMila Complex	200	25	10	30	16

*CAN = calcium ammonium nitrate.

**DAP = di-ammonium nitrate.

*** in some months there are multiple applications of fertiliser of different types.

2.3.2 Irrigation Inputs Gathered.

The Overseer files were also analysed to obtain data for typical irrigation inputs used by commercial vegetable growers including the irrigation application system, irrigation amount and return period, and the trigger and target irrigation application rates for each month of the irrigation season. There was considerable variability in the irrigation inputs used across the various Overseer growers files, some which exceeded Good Management Practices[6] (GMP) and some which did not meet the GMP standards.

Because this exercise is designed to reflect GMP the growers' Overseer data for irrigation was not used. Therefore, irrigation is modelled as the following input options which are entered into Overseer:

- Soil Moisture sensors: the soil moisture probes option was chosen,
- Trigger point and depth applied to achieve target was chosen and,
- The Overseer default was chosen to determine the management systems.

The result of the choices made in electing the irrigation information into Overseer is that the irrigation modelling meets the GMP standards.

3 Commercial vegetable crop rotation scenarios

3.1 Methodology

The Overseer files supplied by the growers were examined to determine whether they represented a standard rotation for root vegetables and green vegetables production types. Each of these types represent a standard rotation used in the commercial vegetable growing sector in Canterbury. It should be noted there were no market garden (the third representative production type) Overseer files available, however two Canterbury growers were interviewed to ascertain their practices and a standard rotation.

It was very difficult to ascertain an appropriate representative commercial vegetable crop rotation from the growers' rotations for a number of reasons, in particular because operations were integrated with a myriad of other non-vegetable land uses. Therefore, it was decided to use the crop rotations which represented the rotations used in the Canterbury Matrix of Good Management (MGM) process which best represented commercial vegetable growing. The following MGM Overseer files were obtained from ECan:

- Crop rotations with greater than 80% of intensive vegetables
- Crop rotation with greater than 10% of green vegetables
- Crop rotation with greater than 10% root vegetables.

Because the MGM Overseer files represent a proportion of non-horticultural land uses, the make-up of the rotations was altered to be most representative of a commercial vegetable growing operation and to only include the data from the crops which we collected from the Overseer files.

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[6] GMP refers to the practices described in the document entitled "Industry-agreed Good Management Practices relating to water quality" which represent the standards of operation that famers have to comply with.

The crop practices which we collected were then substituted into the MGM rotations to more accurately reflect the GMP practices which are being undertaken in the vegetable growing sector.

3.2 Crop rotation scenarios

The scenarios which we created are:

Green Vegetables

Broccoli > Peas > Broccoli > Squash > Broccoli > Ryegrass > Onions > Ryegrass > Cauliflower > Peas

The green vegetable rotation represents the range of predominantly green vegetables that are grown above the ground that are grown on a relatively large scale.

Root Vegetables

Onions > Potato > Ryegrass > Onions > Ryegrass > Carrots > Potato > Ryegrass

The root vegetable rotation represents the root vegetables that are grown below the ground which are interspersed with some crops that are grown above the ground.

Intensive Vegetables

Cauliflower > Spinach > Onions > Broccoli > Squash > Spinach > Cabbage > Broccoli > Sweetcorn

Intensive Vegetable with Fallow

Fallow > Cauliflower > Fallow > Spinach > Fallow > Onions > Fallow > Broccoli > Fallow > Squash > Fallow > Spinach > Fallow > Cabbage > Fallow > Broccoli > Fallow > Sweetcorn > Fallow.

The intensive vegetable rotation represents more of a “market garden” situation where crops are grown for fresh consumption and they are generally planted in small volumes with a number of differing planting dates for each crop class.

A more detailed depiction of each crop with its planting date at the start and the harvest date at the end and the way that they make up the land use of the area for the total period of the rotation is in Appendix 1.

The three modelled rotations were shared with the working group and the growers who contributed their Overseer files, in order to seek feedback on the typical crop rotations and Overseer inputs. The feedback identified a requirement to include a fallow period[7] within the intensive vegetable model. Therefore, a second intensive vegetable model was created (‘Intensive Vegetable with added fallow’) following the same crop rotation with fallow periods following each crop and a rotation having fallow over the winter months.

After discussion with representatives from within the Horticulture industry who were on the working group it was determined that the area under Intensive Vegetable in each NAZ was to be split 50/50 between the original model (Intensive Vegetable) and the model with added fallow periods (Intensive Vegetable with Fallow).

[7] A fallow period is a period between crops when the land is not producing anything.

3.2.1 Overseer nitrogen losses for the crop rotations

The nitrogen losses derived from each of the rotations chosen are as shown in Table 2.

Table 2: Nitrogen losses for each of the rotations modelled.

Crop Rotation	N loss (kg / ha / year)
Green Vegetables	52
Root Vegetables	39
Intensive Vegetables	43
Intensive Vegetables with Fallow	55

4 Overseer files adjusted for soil type and climate

4.1 Methodology

The Overseer files were then modelled to reflect the range of soil types and climatic variables across commercial horticulture land use areas in Canterbury. This activity was informed by reference to a map generated from a HortNZ grower survey undertaken in 2018, which located each of their growers by crop type throughout the Canterbury region by their main address, as shown in Figure 1. It should be noted that the growers may lease land in different areas to the location of their main address.

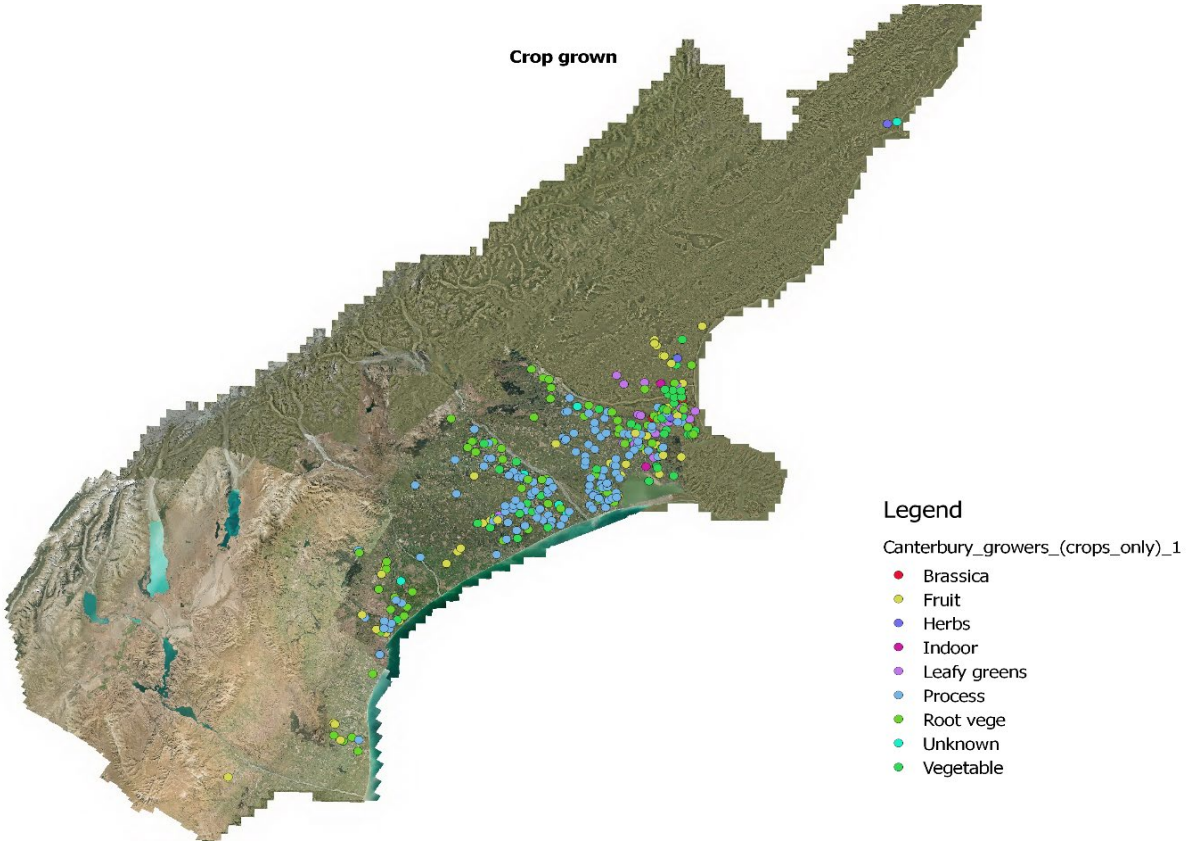

Figure 1. Location of horticultural growers represented by HortNZ in Canterbury.

In Figure 2 the map represents the prime land use for each of the growers surveyed by nutrient allocation zone.

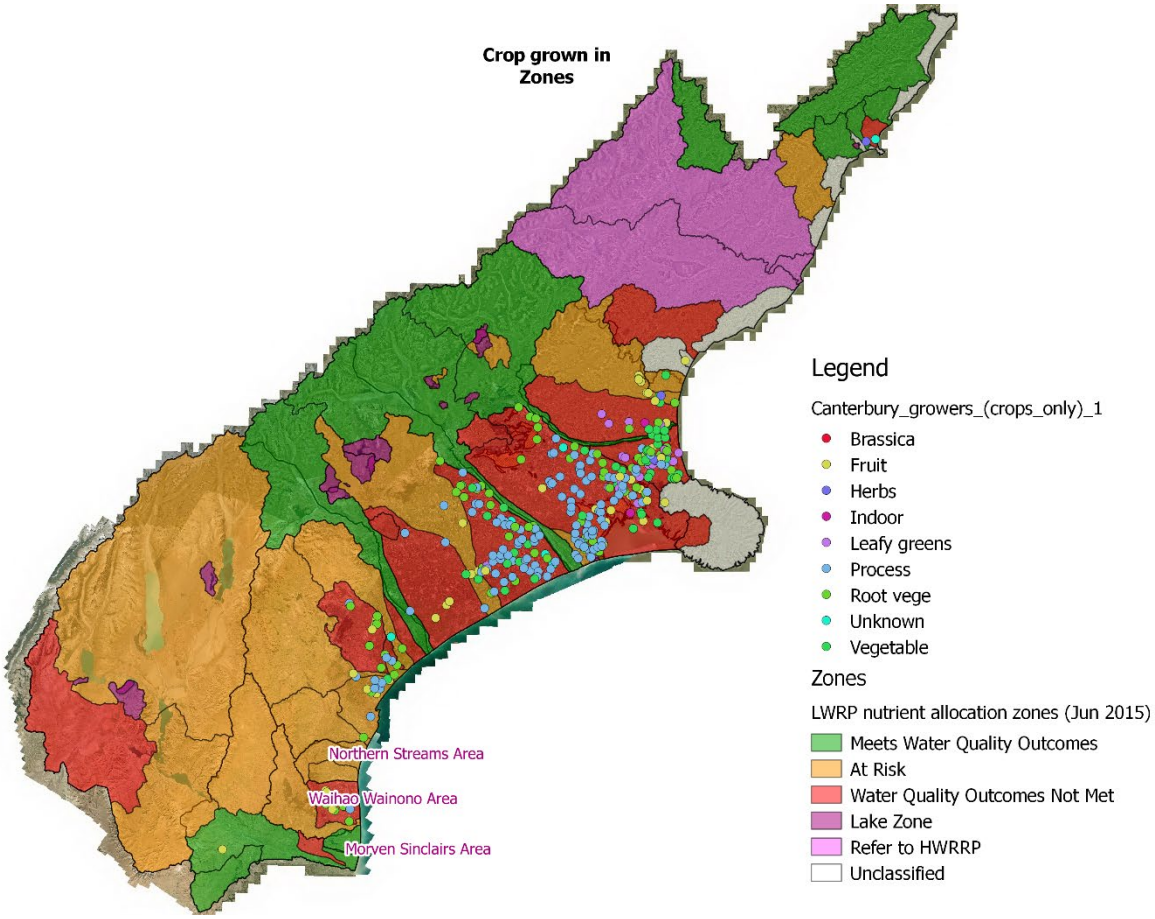

Figure 2. Location of Canterbury growers in nutrient allocation zones

It should be noted that Figure 2 lists a range of crops that are grown in Canterbury. In this exercise we only took account of the 'leafy greens', 'process', 'root vege', 'unknown' and 'vegetable'.

From reference to this map (within GIS) and the soils data available in the Overseer files, we chose the parameters to best represent the range of soil type and climatic variability within the growing area (as shown in **Table 3** and **Table 4**).

The choice of the parameters that were used in describing each of the climate zones that were modelled in Overseer are shown in **Table 3**. The rainfall, temperature and evapotranspiration factors were each calculated by the Overseer tool by nominating a location. The position relative to State Highway 1 (SH1) reflects whether the operation is East or West of SH1.

Table 3: Climatic factors and location used in the Overseer modeling.

Climate Zone Name	Rainfall (mm / year)	Temperature (%)	Evapotranspiration (mm / year)	SH 1
1	656	11.7	888	East
2	554	10.7	752	West
3	714	11.5	879	West

The information used in the choice of the soil types that were modelled were taken from observation of the Landcare soil maps (SMap). They were chosen to represent the range of Plant Available Water (PAW) regimes on which the commercial vegetable crops are grown across Canterbury. The soil descriptions chosen for this exercise are shown in **Table 4**.

Table 4: Soil descriptions used in the Overseer modeling.

Soils	Soil Name	SMap Description	PAW Representative Range (mm)
1	Lismore	Lism_1a.1	60-90
2	Templeton	Temp_2a.1	90-120
3	Waterton	Long_3a.1	+120

4.2 Results

Each of the modelled crop rotations has been modelled in Overseer by each of the climatic zones (C) by each of the soil types (S). This has meant that 36 individual models have been created to reflect the range of these soil and climate variables that commercial vegetables are grown in across Canterbury. The results of this combination of models which was used in the next section of the report are shown in

Table 5,**Table 6** , **Table 7** and

Table 8. The first column of each table specifies the climate (C) and the Soil (S) parameters which were modelled and in the second column it reports the results of the modelling for that combination of parameters as the annual amount of nitrogen leached as Kg N per hectare per year.

Table 5: 'Green Vegetable' rotation soil/climate combinations and nitrogen leaching results.

Soil and climate combination	Kg N / ha / year
C1 S1	71
C1 S2	62
C1 S3	46
C2 S1	49
C2 S2	42
C2 S3	36
C3 S1	74
C3 S2	63
C3 S3	50

Table 6: 'Root Vegetable' rotation soil/climate combinations and nitrogen leaching results.

Soil and climate combination	Kg N / ha / year
C1 S1	54
C1 S2	46
C1 S3	34
C2 S1	40
C2 S2	36
C2 S3	29
C3 S1	58
C3 S2	52
C3 S3	39

Table 7: 'Intensive Vegetable' rotation soil/climate combinations and nitrogen leaching results.

Soil and climate combination	Kg N / ha / year
C1 S1	68
C1 S2	56
C1 S3	42
C2 S1	52
C2 S2	43
C2 S3	33
C3 S1	69
C3 S2	58
C3 S3	48

Table 8. 'Intensive Vegetable with Fallow' rotation soil/climate combinations and nitrogen leaching results.

Soil and climate combination	Kg N / ha / year
C1 S1	84
C1 S2	66
C1 S3	53
C2 S1	67
C2 S2	55
C2 S3	40
C3 S1	86
C3 S2	73
C3 S3	57

5 Typical nitrogen losses for commercial vegetable crops per nutrient allocation zone

5.1 Methodology

In order to model the typical nitrogen losses for commercial vegetable crops in each nutrient allocation zone[8], we calculated, as accurately as possible, the growing area (in hectares) of each of the four crop rotation models. To carry out this exercise we have analysed two different data sources, the Agribase data and the results of the HortNZ growers survey.

5.1.1 Analysis of the available data.

The Agribase data is farm location and farm type data which is collected and recorded by AsureQuality staff as and when they visit a property. The HortNZ growers survey was carried out in 2018.

Agribase data.

The Agribase data (supplied by ECan) includes:

- Catchment zone name
- Area of root vegetables
- Area of green vegetables
- Area of legumes
- Area of other vegetables
- Area of unknown fresh vegetables
- Area of unknown processed vegetables
- Area of unknown vegetables
- Area of Total vegetables.

There are limitations in the accuracy of this data due to the fact that it is collected by AsureQuality when, and if, they have some interaction with the property. Because AsureQuality are the GAP[9] auditors and also administer a number of the crop certification schemes we believe that the data is a reasonable reflection of both the total area of commercial vegetable production and the crops that are grown.

HortNZ data.

The HortNZ data from the grower survey undertaken in 2018 also provided information on crop area. However, this survey only received responses from 94 of the 444 growers (21% response rate). We do not think that this is a representative result which we can use in this analysis. It can however be used for a rough order comparison acknowledging typical response rates from surveys and the fact that the survey data does not provide details of leased land locations (only main address location). That being said, the sum of the crop areas from the HortNZ survey report a total of 8,517 ha used for commercial vegetable production in Canterbury compared with the 12,355 ha

[8] Nutrient allocation zone refers to the allocation of the Canterbury region into geographic zones which reflect the common receiving environment for discharges of nutrients.
[9] GAP is the horticultural industries quality assurance scheme.

reported by the Agribase data, which may indicate that the majority of the survey responses were from the larger growers.

StatsNZ

It was originally thought that StatsNZ would be able to provide a source of data for this exercise, but our inquiry indicated that they do not have data as detailed as that supplied by Agribase and it is therefore not suitable for our purposes.

Consolidation of the LWRP nutrient allocation zones into the LWRP sub-region catchments.

In order for us to be able to model the total nitrogen leached by each LWRP sub-region catchment we combined the crop areas in the nutrient allocation zones in order to incorporate the area of commercial vegetables grown in each LWRP sub-region catchment.

Crop areas per nutrient allocation zone were provided by ECan, who sourced data from AgriBase and StatsNZ . The areas within the various nutrient allocation zones were consolidated to represent the eleven LWRP sub- region catchments as shown in Table 12.

Table 9. Consolidation of the NAZs into the LWRP sub-region catchments.

LWRP sub-region catchments	Nutrient Allocation Zones
Central Canterbury Alpine Rivers	Waimakariri, Rangitata, Rakaia
Ashburton	Ashburton-Rakaia, Ashburton
Banks Peninsula	Banks Peninsula
Hinds	Upper Hinds, Valetta – Hinds, Mayfield/Hinds
Hurunui-Waiau	Waipara, Kowai, Waiau
Kaikoura	Medina, Kahutara, Kowhai, Kaikoura
Orari Opihi Pareora	Washdyke, Orari, Temuka, Pareora, Ohapi Creek Opihi, Makikihi
Waitaki and South Coastal Canterbury	Wainono, Waihao, Morven, Glenavy, Otaio (Waitaki NAZ is excluded as has negligible growers)
Waimakariri	Ashley-Waimakariri, Ashley, Saltwater Creek, Amberley
Selwyn – Te Waihora	Selwyn-Waihora, Little Rakaia
Christchurch-West Melton	Christchurch-West Melton

5.2 Allocation of the areas across LWRP sub-region catcments.

The results of the allocation of areas (ha) of each rotation type into each LWRP sub- region catchment is as shown in **Table 10**.

Table 10: Allocation of areas (ha) into LWRP sub-region catchments

LWRP sub-region catchments	No of enterprises	Root Vegetables (ha)	Green Vegetables (ha)	Intensive Vegetables (ha)	Total Area (ha)
Alpine	6	10	16	18	44
Ashburton	120	3,747	431	493	4,671
Banks Peninsula	5	0	0	0.2	0.2
Christchurch-West Melton	59	81	149	109	339
Hinds	13	228	110	8	346
Hurunui	6	0.75	0	17	18
Kaikoura	6	21	23	0	44
OTOP	48	1,366	110	171	1,647
SCCS	24	434	70	11	515
Selwyn	188	2,997	350	262	3,609
Waimakariri	47	110	17	53	180
Total	**516**	**8,995**	**1,275**	**1,141**	**11,411**

5.2.1 Allocation of the area across the three climatic zones.

The data gained from these two exercises was then split according to a visual inspection of the HortNZ grower location map. This split was two thirds below State Highway One for all of the zones, and one third above (excluding the South Coastal Canterbury catchment which was split 50:50 above and below State Highway One) this split was in order to allocate the area across the climatic zones.

The area for each nutrient allocation zone was then split in climate zones, which were then multiplied by the proportion of soil in each particular nutrient management zone (shown in **Table 11**, **Table 12** and **Table 13**). These percentages were determined by visual assessment of S-Maps, and the growers' (main address) locations.

Table 11. Climate zone 1, soil proportioning per the Land and Water Regional Plan sub-region catchments

LWRP sub-region catchments	S1	S2	S3
Alpine	10%	70%	20%
Ashburton	70%	15%	15%
Banks Peninsula	15%	70%	15%
Christchurch-West Melton	80%	15%	5%
Hinds	80%	15%	5%
Hurunui	10%	45%	45%
Kaikoura	10%	50%	40%
OTOP	5%	20%	75%
SCCS	5%	20%	75%
Selwyn	5%	70%	25%
Waimakariri	10%	45%	45%

Table 12. Climate zone 2 soils proportioning per LWRP sub-region catchments

LWRP sub-region catchments	S1	S2	S3
Alpine	10%	70%	20%
Ashburton	70%	15%	15%
Banks Peninsula	15%	70%	15%
Christchurch-West Melton	80%	15%	5%
Hinds	80%	15%	5%
Hurunui	10%	45%	45%
Kaikoura	10%	50%	40%
OTOP	5%	20%	75%
SCCS	5%	20%	75%
Selwyn	5%	70%	25%
Waimakariri	10%	45%	45%

Table 13. Climate zone 3 soils proportioning per LWRP sub-region catchments

LWRP sub-region catchments	S1	S2	S3
Alpine	5%	70%	25%
Ashburton	65%	25%	10%
Banks Peninsula	15%	70%	15%
Christchurch-West Melton	80%	15%	5%
Hinds	70%	20%	10%
Hurunui	15%	45%	40%
Kaikoura	10%	50%	40%
OTOP	5%	15%	80%
SCCS	5%	15%	80%
Selwyn	5%	25%	70%
Waimakariri	15%	45%	40%

5.2.2 Allocation of the soil types

The split of the soils data was done with reference to the HortNZ grower data and an S-Map map of the soil's types across the region. These split proportions were estimated according to a visual assessment of the data and are shown in Table 15, Table 16 and Table 17.

The areas of each soil and climate combination were then multiplied by the appropriate nitrogen leaching figure which was modelled by Overseer to give the total nitrogen leaching per nutrient management zone.

The results of the allocation of the soils split are shown in **Table 14**.

Table 14: Allocation of areas into LWRP sub-region catchments based on soil type.

LWRP Sub-region Catchment	Soil type 1 Lismore	Soil type 2 Templeton	Soil type 3 Waterford	Total (ha)
Alpine	4	31	10	44
Ashburton	3,195	850	626	4,672
Banks Peninsula	0.03	0.14	0.03	0.2
Christchurch-West Melton	271	51	17	339
Hinds	266	58	23	346
Hurunui	2	8	8	17
Kaikoura	4	22	17	44
OTOP	82	303	1,261	1,647
SCCS	26	95	395	515
Selwyn	180	2,006	1,422	3,609
Waimakariri	21	81	78	179
Total	**4,052**	**3,504**	**3,856**	**11,411**

6 Results

The area of each crop rotation within each of the LWRP sub-region catchments was multiplied by the associated Overseer Nitrogen losses (kg N/ha/yr) which are shown in Tables 8 to11, which were driven by the soils and climate assumptions to get a total Nitrogen loss (kg N/year) from the nutrient allocation zone. The results of this exercise are in **Table 15**.

Table 15. Nutrient losses from the four commercial vegetable operations rotations showing the Total and Average nitrogen leaching by LWRP sub-region catchments.

LWRP sub-region catchments	Root Vegetables (kg N / year)	Green Vegetables (kg N / year)	Intensive Vegetables (kg N)	Intensive Vegetables with Fallow (kg N)	Total Nitrogen leaching (kg N/year)	Average Nitrogen leaching (kg N/ha/year)
Alpine	427	859	467	0	1,753	40
Ashburton	177,023	25,906	14,801	17,851	235,581	50
Banks Peninsula	0	0	5	6	12	58
Christchurch-West Melton	3,970	9,223	3,337	4,097	20,627	61
Hinds	11,038	6,770	252	298	18,358	53
Hurunui	30	0	392	493	916	53
Kaikoura	838	1,190	0	0	2,028	47
OTOP	50,058	5,150	3,774	4,615	63,597	39
SCCS	15,910	3,292	243	297	19,742	38
Selwyn	120,746	17,908	6,358	7,761	152,773	42
Waimakariri	4,456	871	1,256	1,580	8,162	46
Total	**384,496**	**71,170**	**30,885**	**37,000**	**523,551**	**46**

7 Appendices

7.1 Appendix 1