Carbon Neutral Dipton

Offrey Farm Ltd

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Properties Included

Ronaki 112 Winton Channel Road, ***Ben Esk*** 307 Dipton Winton Highway

Executive Summary

Offrey Farm Ltd is owned by John and Clare Officer and consists of Ronaki Dairy (267.8 ha) located at 112 Winton Channel Road, Kauana and Ben Esk (186 ha) located at 307 Dipton Winton Highway, Benmore. The properties are part of the Carbon Neutral Dipton Catchment Project investigating the effects that farmer led farm system changes may have on total farm biogenic greenhouse gas (bGHG) emissions, and financial performance when modelled in OverseerFM and Farmax.

Four scenarios have been modelled as part of the desktop study with comparison made to the Base farm system. The modelling has focussed on the parameters for total biogenic Greenhouse Gas emissions, nitrogen losses and earnings before interest and tax (EBIT). The four scenarios modelled have varied effects on bGHG emissions, nitrogen losses and profitability.

Biogenic emissions reported in this study align with the definition used by the He Waka Eke Noa Programme team. It includes methane and nitrous oxide emissions associated with livestock production plus nitrous oxide and carbon dioxide associated with the dissolution of nitrogen fertiliser and lime (He Waka Eke Noa, 2022).

Any farm system change reducing the total kilograms of feed eaten on farm should reduce methane emissions and therefore total bGHG emissions.

The current farm system (Scenario One) which represents changes from the Base including lower milking cow numbers, importing less supplement and selling some supplement from the support block results in a 10.6% reduction in bGHG emissions across the farm business. This scenario reduces EBIT due to the lower modelled returns from selling beef compared with milk.

Two scenarios focussed on other ways to reduce dry matter intake through reducing replacement rates and growing an arable crop (Scenario Two) or substituting areas of low productivity for forestry (Scenario Four). These scenarios both had a positive impact on EBIT and reduced bGHG emissions. The change of land use from grazed pasture to an arable barley crop slightly increased nitrogen loss. Consideration into the broader environmental impacts of farm system change is required to ensure that a proposed farm system change that improves one aspect (bGHG emissions in this case), does not adversely impact other aspects.

Finishing beef cattle prior to their second winter (Scenario Three) whilst harvesting the same amount of home-grown feed through carrying higher stock numbers had little impact on bGHG emissions. This change reduced EBIT due to the increased price of calf rearing, finishing animals lighter and at a lower schedule price in autumn compared with spring.

There is no "one size fits all" solution or silver bullet to reducing bGHG emissions and nutrient losses. Farm businesses will require a multi-layered approach and implementation of multiple mitigations. Time will also be required to see these changes take effect and contribute to the above-mentioned outcomes. Mitigation options must also be customised based on resource availability and farmer objectives.

The scenarios modelled in this report indicate that changes in bGHG emissions, nitrogen losses and financial performance are possible as a result of specific farm system changes. Further investigation into the broader practicality of these options is recommended before significant changes are adopted by farmers.

This report focusses primarily on total biogenic emissions, however, where production is improved per unit of biogenic greenhouse gas, (i.e., where intensity is reduced) it is also noted.

Farm Summary Reports, nutrient budgets and Farmax output are available with this summary report.

The OverseerFM® v6.5.1 modelling undertaken for the purpose of this report was prepared by a certified nutrient management advisor using the OverseerFM® Knowledge Base user guidelines (previously referred to as the Best Practice Data Input Standards).

Contents

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1. Introduction

Offrey Farm Ltd consists of a 151 ha dairy platform “Ronaki” with two adjoining lease blocks which total 116 ha, located 112 Winton Channel Road, Kauana. This farm is operated as a dairy farm with support on farm and is comprised of all flat highly productive paddocks. The farm business also includes a 186 ha block “Ben Esk” located at 307 Dipton Winton Highway, Benmore, which is operated as a dairy support and beef finishing block and is comprised of flat paddocks to rolling country.

Offrey Farm Ltd is part of the Dipton Catchment Groups “Carbon Neutral Dipton” project to identify options to reduce total biogenic greenhouse gas (bGHG) emissions on farm. Agri Magic was contracted to investigate and report the environmental and financial implications of possible farm system changes with the aim of reducing biogenic greenhouse gas losses on five case study farms.

Biogenic emissions reported in this study align with the definition used by the He Waka Eke Noa Programme team. It includes methane and nitrous oxide emissions associated with livestock production plus nitrous oxide and carbon dioxide associated with the dissolution of nitrogen fertiliser and lime (He Waka Eke Noa, 2022).

Methane emissions are driven predominantly by animal Dry Matter Intake (DMI). For every kgDM that passes through the rumen an amount of methane is produced.

Nitrous oxide emissions are associated with soil processes. In the nitrogen cycle there are two main routes by which nitrous oxide is lost from the soil. One of these is via volatilisation of nitrogen when it is applied to the surface as dung, urine or fertiliser. The second route by which nitrous oxide can be lost from the soil is through the conversion of ammonia to nitrate by soil microbes. Both pathways are influenced strongly by weather, i.e. wind, temperature and moisture. Reducing the amount of nitrogen in the total soil pool is one way to reduce the risk of nitrogen losses either to the atmosphere as nitrous oxide or to ground water as nitrate. An optimised system will ensure enough plant available nitrogen but little excess, applied with careful consideration to the weather.

Carbon dioxide associated with biogenic emissions is generated with dissolution of lime and nitrogen fertiliser.

Non biogenic GHG emissions such as the burning of fossil fuels which release carbon dioxide have been excluded from the scenario modelling and reporting.

New Zealand’s GHG reduction targets (linked to global agreements) require a reduction in total emissions. Our market opportunities often focus on our low intensity of emissions per unit of product. Mitigations modelled and this report focus on the total bGHG emissions from the property. Farm system or management changes which improve emissions intensity such as increased production per kg DM consumed and lower empty rates are likely to improve profitability but may not reduce total GHG emissions unless the total amount of dry matter eaten within the farm system also reduces. Fluctuations in annual pasture production due to climatic variations leading to differences in feed eaten within a year may also impact bGHG emissions. Consideration to these variations when deciding on farm system changes is important.

New technologies that are looking to decouple methane production from dry matter intake are currently being researched but are unlikely to be commercially available prior to 2030. Our first reduction targets may need to be met through making changes to our farm system, hence the focus of this study.

2. Method

The following method was used for each of the case study farms:

- A Base farm system (represented as the 2021-22 season) was modelled in both OverseerFM and Farmax. OverseerFM was used to establish biogenic greenhouse gas emissions and nutrient losses. Farmax was used to ensure farm system feasibility and to quantify the effects of the farm system changes on profitability. The Base farm system is detailed in Appendix 6.3.
- Meetings were held with farmers' John and Clare and their buddy group to discuss possible future farm system options.
- Four scenarios were chosen to compare with the Base situation. The scenarios were:
    1. Reduced milking cow numbers and increased beef cross finishing to represent the current farm system operated. Scenarios 2,3 and 4 were all changed relative to Scenario One.
    2. Lower replacement rate, arable barley crop grown.
    3. Beef cross animals finished prior to winter. Increased total numbers grazed to ensure similar pasture production.
    4. 9 ha of forestry planted in areas of low production.
- Initial findings have been summarised into this report.
- Contact with case study farms to discuss findings, and contribution to field days for project.

Further details on the scenarios modelled have been provided in Appendix 6.4

2.1 Modelling Assumptions

- Product prices and farm expenses were standardised based on the Farmax database across all scenarios. Changes to assumptions for each scenario where relevant have been provided in Appendix 6.4.
- An indication of the GHG farm level pricing levy has been included in the financial implications of each scenario in line with the method used in the consultation document for He Waka Eke Noa programme (He Waka Eke Noa, 2022). This indication has been calculated based on GWP^{100} with a carbon price of \$85/t CO_2 equivalents, with a 95% discount rate. This has been provided as an indication only. It will be important to stay up to date as decisions on He Waka Eke Noa are released.
- Income from forestry included in the modelling has been accounted for under the Emissions Trading Scheme (ETS) rather than used as an offset under HWEN.

3. Results and Discussion

The results have been summarised in tables and graphs. These results have been compared to the Base farm system to quantify the change in biogenic greenhouse gas emissions, nitrogen losses and estimated earnings before interest and tax.

The biogenic GHG emissions, and nitrogen losses for the Base and scenarios as calculated by OverseerFM are summarised in Table One.

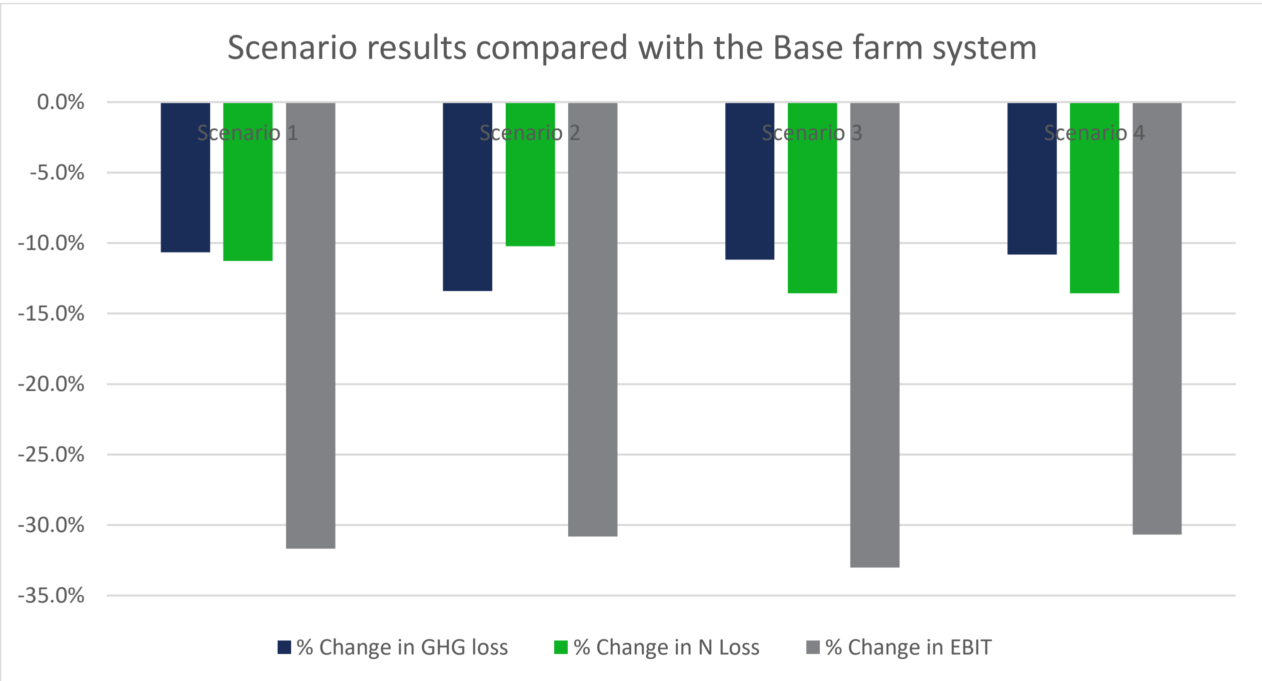
Table One: Base and Scenario biogenic greenhouse gas emissions, nitrogen losses and EBIT for Offrey Farm Ltd

	Base	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Scenario details	Base	Current steady state	Lower replacement rate	Animals finished early	9 ha of trees
Total bGHG Emissions (tCO_2E)	3,970	3,547	3,438	3,526	3,541
N Loss per ha (Kg N/ha/yr)	44	39	39	38	38
N Loss per year (Kg N/yr)	19,763	17,535	17,742	17,084	17,084
Change in EBIT	From Base	- 31.7 %	- 30.8%	- 33.0%	- 30.7%
	From current steady state		+ 1.3%	- 1.9%	+ 1.5%

** Please note this output includes biogenic emissions only and does not consider the sequestration of forestry as an offset.

The change in biogenic GHG emissions, nitrogen losses and profitability (EBIT) for the scenarios compared to the Base farm system have been illustrated in Figure one.

Figure One: Percentage change in Overseer derived biogenic greenhouse gas emissions and nitrogen losses and Farmax derived EBIT for each scenario compared to the Base farm system.



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The Base farm system had an OverseerFM total biogenic greenhouse gas loss of 3,970 eCO2 t/yr and a nitrogen loss of 44 kg N/ha/yr.

Scenario One represents the current steady state farm system with the changes already made since the Base 2021-22 season. In comparison to the Base, the current system has reduced milking cow numbers with an increase in dairy beef with most beef cross calves grazed for two years and finished in the spring as 2 year olds. Compared with the Base system, the steady state system has reduced bGHG losses by 10.7% and nitrogen losses by 11.3%. It also results in a reduction in EBIT of 31.7% due to lower returns from beef compared with milk based on current pricing levels. The reduction in bGHG emissions is due to a reduction in total dry matter eaten across the two farms with less supplement imported for the dairy farm and some baleage harvested and sold from the support block. Directly replacing dairy cows with beef cows and eating the same total feed per year is unlikely to reduce bGHG emissions.

All subsequent scenarios have been modelled with changes made from Scenario One (the current steady state system) therefore results of subsequent scenarios have been compared to Scenario One.

Scenario Two represents lower replacement rates and less carry over cows grazed based on improving in-calf rates within the dairy herd. There was no change in milking cow numbers or production modelled. The reduction in pasture demand from reduced replacements allows for the introduction of an 18 ha barley crop of which the grain was then fed to dairy cows to replace imported supplement. Compared to Scenario two, this scenario reduced bGHG emissions by 3.1% and increased EBIT by 1.3% however also increased nitrogen losses by 1.2%. The reduction in bGHG emissions is due to lower total feed eaten across the farm business whilst maintaining similar productivity. The minimal increase in EBIT is likely to be within the margin of error and potential gains in herd performance from a higher replacement rate may outweigh the reduced bGHG emissions which could be achieved. Minimising the amount of feed fed for maintenance or to an animal not producing a saleable product such as replacements or carry over cows should reduce bGHG emissions per unit of production (emissions intensity) however reductions in methane emissions can only be achieved if the total amount of feed consumed is reduced across the farm business. The increase in nitrogen losses is likely due to the increased nitrogen mineralisation following cultivation for cropping compared with long term dairy pasture. Consideration into all environmental impacts of farm system change is required to ensure that a proposed farm system change that improves one aspect (bGHG emissions in this case), does not adversely impact other aspects.

In Scenario Three, beef cross cattle were sold through autumn prior to their second winter as opposed to selling in spring post their second winter on farm. This allowed for an increased number of calves to be finished whilst maintaining similar total feed requirements. This scenario resulted in a reduction in bGHG losses by 0.6% and nitrogen losses by 2.6% however also reduced EBIT by 1.9%. There was very little change in total kilograms of dry matter eaten across the year therefore the changes in bGHG emissions were minor. The reduction in EBIT for Scenario Three is due to increased costs to rear more calves, reduced finishing weights due to selling cattle earlier in autumn and reduced schedule prices through autumn compared with early spring. This reduction in EBIT is based on the assumption that cattle will be finished lighter prior to winter. If cattle can be grown faster and sold at similar weights in a shorter time, EBIT in this scenario will increase. To minimise the weight gap, a focus on liveweight gain would be required throughout the season with reduced flexibility if climatic variations effected feed supply and quality. Reducing stock numbers on farm over winter reduces nitrogen losses due to lower stocking rates during a time of low plant nitrogen uptake and higher drainage volumes. It should be noted that the changes seen in this scenario are minor and possibly less than naturally occurring annual variation caused through a change in pasture production (e.g., wet season versus dry).

Scenario Four represents 9 ha being converted from pasture to production forestry. This scenario reduces biogenic GHG losses by 0.2% from Scenario One and nitrogen losses by 2.6% while increasing long term average farm EBIT by 1.5%. The increase in EBIT is due to the improvement in returns from production forestry ($1,225/ha), compared to the current estimated profitability from the lower performing 9 ha. Cashflow per hectare for the forestry blocks is $1,225 when averaged over 33 years. Approximately a third of this comes from carbon and two thirds from harvesting at the end of the 33-year rotation. Because of the nature of forestry, the increase in EBIT is calculated over the full life of the trees. By year six the carbon revenue starts outweighing the cost of establishment (Frengley, 2023).

4. Conclusions

Findings indicate that reductions in bGHG emissions can be achieved by reducing dry matter intake across the business. This has been achieved in the current farm system through a reduction in stocking rates and supplement imported. Reductions in dry matter intake can also be achieved by growing less replacements and replacing the area with an arable crop. The impact on profitability from these changes varies and depends on the impact on herd performance or any reduction in milk production from the farm system change.

The change of land use from grazed pasture to an arable barley crop reduced dry matter intake however this contributed to increased nitrogen losses. Consideration into all environmental impacts of farm system change is required to ensure that a proposed farm system change that improves one aspect (bGHG emissions in this case), does not adversely impact other aspects.

Reductions in both bGHG emissions and nitrogen losses can be achieved through the change of land use from pasture to production forestry. Focussing this change on lower performing areas of the farm where less dry matter in total is grown and harvested by animals results in improved long-term profitability as well as a reduction in bGHG emissions. In the modelling, this also contributed to reduced nitrogen losses. The increased profitability is due to forestry returns outweighing the returns from that 9 ha being in pasture. In practice, the harvest of timber can cause significant point source nutrient losses which are not represented in the OverseerFM model.

There is no “one size fits all” solution or silver bullet to reducing bGHG emissions and nutrient losses. Farm businesses will require a multi-layered approach and implementation of multiple mitigations. Time will also be required to see these changes take effect and contribute to the above-mentioned outcomes. Mitigation options must also be customised based on resource availability and farmer objectives.

Please note the scenarios modelled in this report indicate likely changes in bGHG emissions, nitrogen losses and financial performance. Further investigation into the pragmatism of these options is recommended.

5. References

He Waka Eke Noa agricultural emissions pricing options, pg 5 (2022). https://hewakaekenoa.nz/wp content/uploads/2022/01/Consultation-Document_Final.pdf

Frengley, D. (2023). *Forestry and Sequestration Report Offrey Farms Ltd*

6. Appendix

6.1 Farm Property Information

The dairy platform (including lease blocks) is 267.8 ha and is located at 112 Winton Channel Road, Kauana.

There are three soil types associated with this property, as identified by Landcare Research's S Maps:

- Pukemutu deep (Pukem_6a.1, poorly drained, PAW_{60} = 93 mm);
- Caroline moderately deep (Carol_6a.1, poorly drained, PAW_{60} = 99 mm);
- Makarewa deep (Makar_3b.1, poorly drained, PAW_{60} =107 mm).

The runoff block is 186.0 ha and is located at 307 Dipton Winton Highway, Benmore.

There are two soil types associated with this property, as identified by Landcare Research's S Maps:

- Claremont deep (Clar_34a.1, poorly drained, PAW_{60} = 92 mm);
- Balmoral shallow (Balm_21a.1, well drained, PAW_{60} = 71 mm).

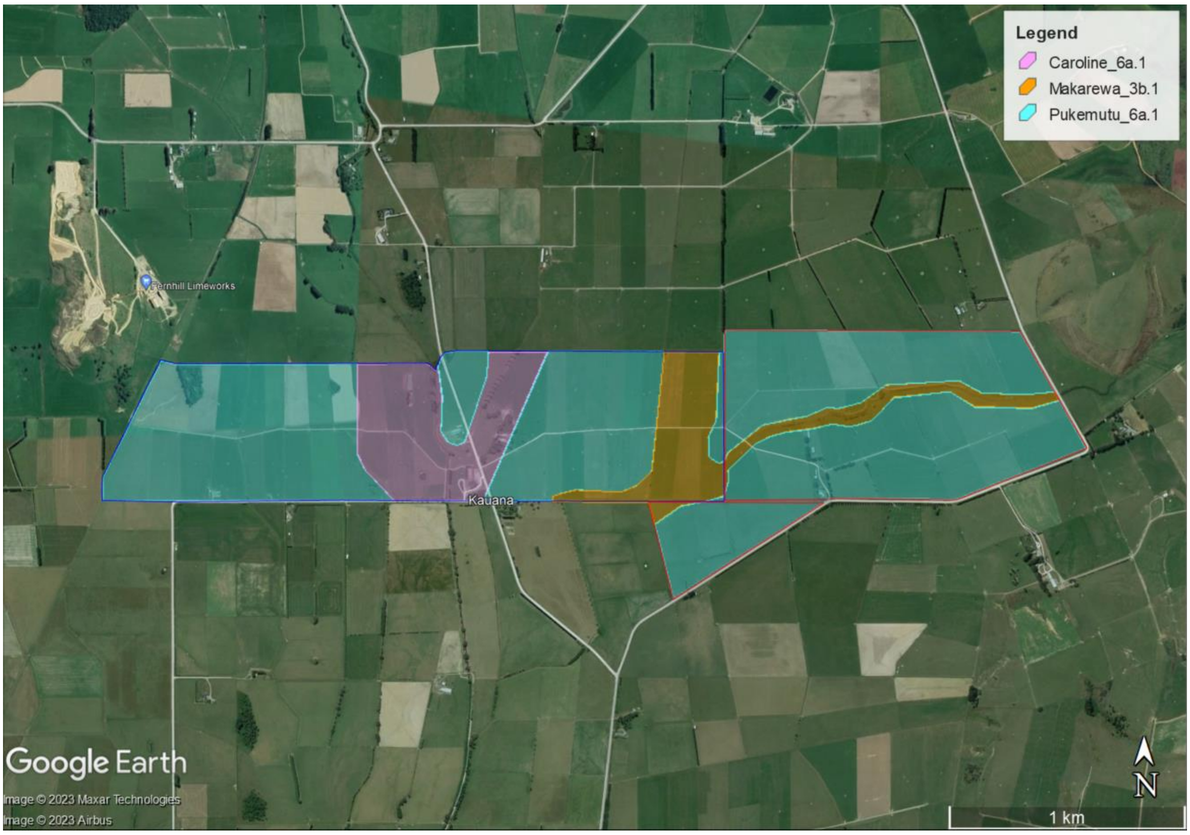
Note: PAW_{60} = profile available water to 60 cm

Climate data for these properties has been sourced from OverseerFM®'s climate station tool and input as:

- Rainfall = 1,063 mm/yr
- PET = 684 mm
- Average temperature = 9.9°C
- Property Co-ordinates: -45.920727, 168.36129

6.2 Property Outline and Soil Map – Google Earth

6.2.1 Dairy Platform and Lease Blocks



6.2.2 Runoff Block

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6.3 Base Inputs (2021-22 Season)

During the Base season these properties were run together as a farming enterprise with a dairy platform, all cows wintered on farm, all replacements grazed on farm and some beef cross calves reared and finished prime.

Area:

- 453.8 ha title area
  - 413.2 ha productive
  - 8.7 ha of trees and scrub

Crops:

- 5 ha of fodder beet on dairy platform
  - Grown in *Pasture > FB > GFO > Pasture* rotation.
  - Sown in October with 350 kg/ha of Fodder Beet Base (minimum tillage).
  - 18 t DM/ha yield grazed April-May by cows.
  - Followed by a catch crop of forage oats.
    - Sown in June (minimum tillage).
    - 5 t DM/ha yield grazed in spring by cows.
    - Sown back into pasture in December.
- 6 ha of fodder beet on runoff block.
  - Grown in *Pasture > FB > FB > Pasture* rotation.
  - Sown in October with 350 kg/ha of Fodder Beet Base (minimum tillage).
  - Side dressing of Urea in March at 10 kg/ha.
  - 18 t DM/ha yield grazed June-August by cows.
- 36ha of kale on runoff block.
  - Grown in *Pasture > Kale > GFO > Kale > Pasture* rotation.
  - Sown in December with 100 kg/ha of SustaiN and 100 kg/ha of Muriate of Potash (direct drilled).
  - Side dressing of Urea in March at 10 kg/ha
  - 12 t DM/ha yield grazed June-August by cows.
  - Followed either by a catch crop of forage oats (18 ha);
    - Sown in September (minimum tillage).
    - 6 t DM/ha yield cut for silage in November.
  - Or sown back into permanent pasture in September.
- 33 ha of forage barley on runoff block.
  - Gown in an *Annual RG > Barley > Pasture* rotation.
  - Annual RG sown in September (direct drilled).
  - Forage barley sown in August (direct drilled).
  - One side dressing of Cropzeal 16N at 250 kg/ha in November.
  - 7 t DM/ha yield cut for silage in December.
  - Sown back into pasture in January.

Stock:

- 690 F x J cows peak milked
  - 317,000 kg milk solids produced (460 kg MS/cow)
  - All wintered on runoff
- 101 R1 replacement heifers; end weight in June 230 kg LWT
- 185 R2 replacement heifers; end weight in June 470 kg LWT

- 60 carry-over cows
- 10 R2 F x J bulls
- 9 MA F x J bulls
- 145 beef X heifer calves; end weight in June 250 kg LWT
- 115 beef X R2 heifers; 30 finished in January at 500 kg LWT, end weight in June for remainder 480 kg LWT
- 56 beef X bull calves; end weight in June 260 kg LWT.

Fertiliser:

- Dairy pasture blocks received 221 kg N/ha in the form of Ammo-31, N-Protect, Urea, SustaiN 25K, Flexi-N & N-rich Liquid Urea 19N.
- Runoff pasture blocks received 118 kg N/ha in the form of Ammo-31, N-Protect, Ammo36, Urea, SustaiN 25K, & SustaiN.

Supplementary Feed:

- 275.7 t DM sileage harvested and fed back.
- 308 t DM cereal silage harvested and fed back.
- 250 t DM palm kernel imported.
- 145 t DM brewers grain imported.

Effluent:

- Liquid effluent spread at an application depth of 12-24 mm

6.3.1 Base Dairy Platform Management Blocks

	TYPE	AREA (HA)
DAIRY CAROLINE_6A.1 PASTURE	Pasture	27
DAIRY MAKAREWA_3B.1 PASTURE	Pasture	22
DAIRY PUKEMUTU_6A.1 PASTURE	Pasture	193.5
SUPPORT BALM_21A. PASTURE	Pasture	7.5
SUPPORT CLAR_34A.1 PASTURE	Pasture	24.2
DAIRY PUKEM_6A.1 FB>OATS>PASTURE	Crop	5
DAIRY PUKEM_6A.1 PASTURE>FB>OATS	Crop	5
SUPPORT CLAR_34A.1 ANNUAL-BARLEY-PASTURE	Crop	33
SUPPORT CLAR_34A.1 FB-FB	Crop	3
SUPPORT CLAR_34A.1 FB-PASTURE	Crop	3
SUPPORT CLAR_34A.1 KALE-OATS - KALE	Crop	18
SUPPORT CLAR_34A.1 KALE-PASTURE	Crop	18
SUPPORT CLAR_34A.1 PAST-FB	Crop	3
SUPPORT CLAR_34A.1 PASTURE-ANNUAL	Crop	33
SUPPORT CLAR_34A.1 PST-KALE	Crop	18
TREES	Trees and scrub	8.7

6.4 Scenario Farm Systems Modelled

Four scenarios have been modelled to represent the options Offrey Farm Ltd see applicable to their farm system. The scenarios are aligned with the Base farm system with changes to each scenario outlined below:

6.4.1 Scenario One:

Scenario One represents the current steady state system that is operated on farm. This system has a reduced milking herd and an increased beef enterprise.

Stock:

- 460 F x J cows peak milked.
  - 225,800 kg milk solids produced (490 kg MS/cow).
  - All wintered on runoff.
- 105 replacement heifers retained annually.
- 50 carry-over cows.
- 23 MA F x J bulls.
- 110 beef X heifer calves reared; on farm for two winters, finished in September/October as 2 yr olds at 550 kg LWT.
- 134 beef X bull calves reared;
  - 30 on farm for one winter, finished prior in the autumn as R2s at 550 kg LWT.
  - 104 on farm for two winters, finished in September/October as 2 yr olds at 600 kg LWT.
- 13 beef breeding cows.

Fertiliser:

- Dairy pasture blocks received 190 kg N/ha in the form of Ammo-31, N-Protect, Urea, SustaiN 25K, Flexi-N & N-rich Liquid Urea 19N.
- Runoff pasture blocks received 154 kg N/ha in the form of Ammo-31, N-Protect, Ammo36, Urea, SustaiN 25K, & SustaiN.

Supplement:

- 275.7 t DM silage harvested and fed back.
- 308 t DM cereal silage harvested and fed back.
- 200 t DM baleage harvested and exported.
- 120 t DM palm kernel meal imported.

All subsequent scenarios have been modelled with the stocking enterprises more closely aligned with Scenario One. Changes from Scenario One have been outlined for the following scenarios.

6.4.2 Scenario Two:

- Lower replacement rate.
  - 80 replacement heifers retained annually.
  - 25 carryovers retained.
  - 120 beef X heifers reared and finished.
- 18 ha of barley crop grown following second rotation of kale.
  - *Past > Kale > GFO > Kale > Barley > Pasture.*
  - Sown in September with 16 kg/ha of N-Protec and 103 kg/ha of Ammo 31 (minimum tillage).
  - One side dressing of N-Protect in October at 100 kg/ha.
  - 8 t grain/ha harvested in March.

- Sown back into pasture in March.

6.4.3 Scenario Three:

- Beef cross fattening stock finished prior to their second winter on farm.
  - 150 beef X heifer calves; on farm for one winter, finished in April/May as R2s at 500 kg LWT and a schedule of $5.50/kg cwt rather than approximately $6.00/kg cwt in spring.
  - 150 beef X bull calves; on farm for one winter, finished in May as R2s at 550 kg LWT and a schedule of $5.50 rather than approximately $6.00/kg cwt in spring.

6.4.4 Scenario Four

- 9 ha of pines planted on the support block in areas of low productivity based on Don Frengley's report. No change to stock numbers due to the low productivity of the area converted. Forestry estimated to return a long-term average of $1225/ha.

6.5 Breakdown of biogenic GHG emissions for Base and scenario farm systems

Table Two: Breakdown of Biogenic GHG emissions for the Base and Scenario farm systems

eCO2 (carbon dioxide equivalents) tonnes/yr				
	Methane GHG Emissions	N20 GHG Emissions	C02 GHG Emissions	Total GHG Emissions
Base	2,994	859	117	3,970
Scenario 1	2,654	786	107	3,547
Scenario 2	2,578	757	103	3,438
Scenario 3	2,635	784	107	3,526
Scenario 4	2,654	782	105	3,541