Owl Farm - St Peters School, Cambridge, Waikato

‘Greenhouse gas and nitrogen loss mitigation in Central Waikato’

A 2019 case study on environmental performance and its effect on production and profitability

Executive Summary

Owl Farm is a 160-hectare dairy unit, owned by St Peters School, Cambridge and is a demonstration farm run for the benefit of the school, the students, the local community, and the dairy industry.

The farm produces around 1150kg MS/ha, 400kg MS/cow from a spring-calving herd of 400-450 cows. The farm employs a farm manager and two staff members. Farm objectives are to improve economic and environmental sustainability.

In recent seasons, Owl farm has reduced its reliance on purchased maize silage and PKE and has increased reliance on pasture and other feed grown on the milking platform. The result has been increased profit from lower production due to cost reductions. Compared with 2014/15, the 2018/19 season saw a reduction in the use of imported supplement by 2.1 t DM/ha, a 50% reduction. This has resulted in:

- a 32% increase ($466/ha) in operating profit/ha at a standardised milk price of $6.00kg/MS
- a 15% decrease in total GHG CO_2 eq. emissions, from 14.3 t CO_2e/ha to 12.1 t CO_2e/ha, a 2.2 t CO_2e/ha reduction[1]
- a 20% decrease in N leaching from 41kg N/ha to 33kg N/ha.

The reduction in GHG emissions was not a focus, but was a consequence of important changes in two drivers of Owl Farm's emissions profile:

1. Reducing farm N surplus by 28kg N/ha (-14%).
2. Reducing total feed eaten by 1.3 t DM/ha (-8.0%).

Two principles helping to achieve reductions in GHG emissions and N leaching at Owl farm are applicable across many farms. They are:

1. Reducing whole farm N surplus. N surplus = N inputs (fertiliser N, imported supplement N, clover N fixation, N in irrigation water) minus N outputs (N in milk and meat).
2. Reducing total feed eaten/ha (mainly by reducing milk production) while maintaining profit by reducing costs for N fertiliser, supplement purchases and other direct costs. Owl Farm achieved higher pasture grown with reduced N fertiliser through improved pasture monitoring. However, as farms become more efficient, it will become more difficult to reduce emissions profitably.

[1] In the first three seasons of this analysis there are inconsistencies between the inputting of data into Overseer and the records of feed use reported by Owl farm. We are in the process of examining these historical files to bring greater certainty to the quantitative assessment of change over time, although similar trends of improvement are evident in each dataset.

Farm Overview

Owl Farm aims to apply proven research and utilise good farm practice to provide leadership for fellow dairy farmers on issues relating to improved dairy farming. Owl Farm has developed a public profile and following. In recent seasons they have transitioned away from a farm system which relied more heavily on purchased maize silage and PKE, towards a system more reliant on pasture and feed grown on the milking platform. They have increased profit with reduced production while still transitioning from the previous system. They are interested in developing a farm system that will result in sustainable profit and meet sustainability targets around environment KPI's (key performance indicators), and employee performance and satisfaction.

Owl Farm has a well-established, cross-bred herd of high genetic merit. They have invested in new pastures recently and plantain has been established in the sward on part of the farm. Imported feed is about 10% of the total annual feed supply, down from about 22% two years ago. Calving is in early July and nitrogen (N) used is 150-160kg N/ha/year. Production is at the Waikato average for MS/ha (1150 kg/ha) and is slightly above average for MS/cow (417 kg/cow).

In 2015-2016 operating profit had declined to - $1200/ha, well below the Waikato benchmark from DairyBase of $100/ha for that season. Operating profit increased to $3090/ha in the 2017/2018 season compared with the Waikato benchmark of $2661/ha and has continued to be above the Waikato benchmark for the 2018-2019 season.

"Owl farm must reflect our consumers' requirements. As part of the global community, we have obligations to produce food and minimise our effect on the planet. Looking at the issues critically, there are some easy runs, but it gets harder when you come across trade-offs. Through the GHG partnership project we focused on harvesting more home-grown feed. We reduced inputs, reduced outputs and improved profitability and environmental outcomes. We became more aware of the relationships within a farm system and farmer goals. We now compare our GHG emissions profile with our other Wagon Wheel KPIs so that informed choices are made on how our system evolves to meet our goals. Aiming for higher profitability, we make sure that investment is in areas that reduce our emissions and add true productivity. Changing systems to reduce our footprint requires us not to degrade our workplace quality or create animal welfare concerns. GHGs have now become part of our data collection and annual planning and reporting." – Jo Sheridan, Owl farm manager

Farm Vision

To apply proven research, utilising good on-farm practice, and scientific monitoring for the farm to:

- become an exemplar in dairy production, financial, environmental, and people performance, while maintaining the highest standards of health of safety
- encourage more young people into the dairy industry through demonstration to students.

Goals

Dairy Farm

- Provide leadership to dairy farmers and the wider community by demonstrating progressive practices that can be achieved on farm.
- Optimise profit through identifying the appropriate dairy production system for Owl Farm.
- Achieve a farm environmental footprint based on industry good management practice.
- Attract, train, and retain quality employees.

Students

- Provide educational opportunities and exposure to the dairy industry that demonstrate career opportunities.

Environmental Objectives

- Implement sound science-supported environmental management systems to achieve sustainable growth and profit while protecting the wider environment.
- Ensure compliance with all regulatory and industry requirements.
- Engage with stakeholders, to lead towards sustainable farming objectives while influencing future direction.
- Show leadership by establishing biodiversity management practices relevant to the Waikato.

Values

- The farm's reputation is important being in the public eye and must be seen to be operating safely, cleanly and taking good care of stock.
- The workplace environment will not be compromised, staff retention is valued, so the job must be manageable, with low stress and high job satisfaction.
- Owl Farm has a leadership role in the industry, so any changes must be replicable and relevant to other farmers.
- Maintain a genetically closed herd.
- Progress towards environmental goals must occur.
- Maintain a 'pasture first' grazing system with home-grown feed next.

Farm Map

Figure 1: Farm Map

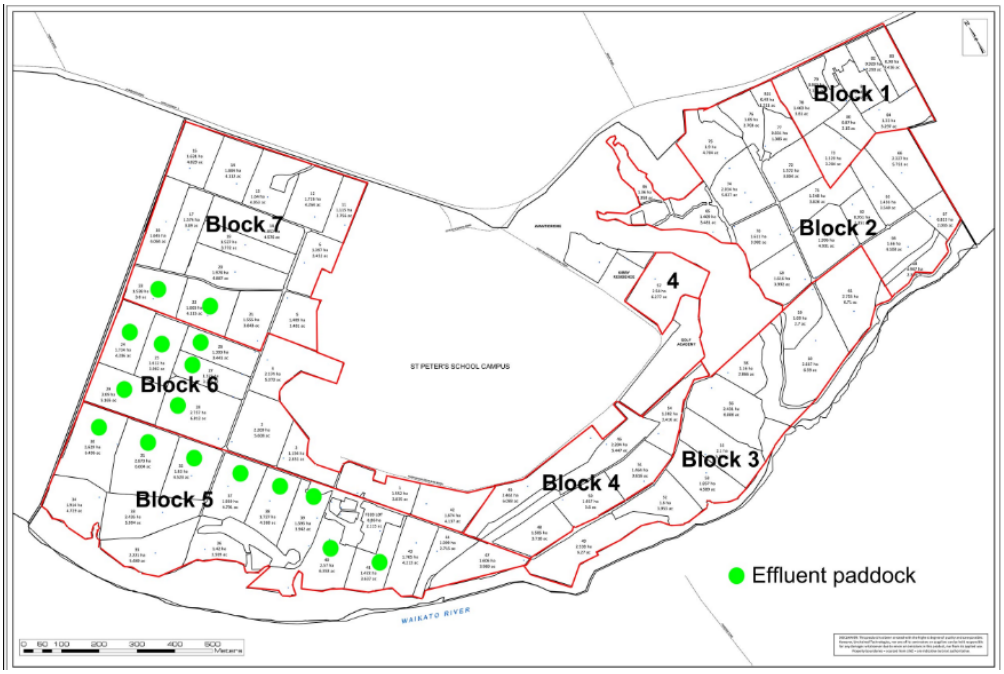


Figure 1 shows Owl Farm's nutrient management blocks. Owl Farm surrounds the St Peters School and has the Waikato River on one boundary, and Cambridge Road (formerly SH1) on the other.

Table 1: Owl Farm Key Farm System Details 2016-2017

Farm Details		**Farm System Details 2016-2017**	
Nearest town and catchment	Cambridge. Waikato	Herd size	423
Season's rainfall (Overseer)	1166 mm	Breed and live weight (kg)	Crossbred 475 kg
Soil type(s)	Otorohanga deep clay. Pukehina deep sand Kainui deep silt clay Turangi deep sand Rotokauri deep clay loam Kaipaki deep peat	Farm system (% feed brought in)	20%
Terrain (flat/rolling/hilly)	Flat contour over 3 terraces	Stocking rate	2.9 (cows/eff ha)
Total farm size	164ha	Comparative stocking rate	7 kg LWT/t DM
Effective area	147ha	Per cow production (kg)	421kg MS
Support block (ha, location, owned/leased)	18ha	Per hectare production (kg)	1221kg MS/ha
Labour (FTE)	3.0	Planned start of calving	3rd July
Irrigation area (ha)	0	Calving spread 3/6/9 weeks	68%/85%/96%
Effluent irrigation area (ha)	54ha	BW (22nd April 2019)	119 (top 10%)
Irrigation type	none	PW (22nd April 2019)	153 (Top 10%)

Stand-off pad/herd home infrastructure	none	Young stock	Off farm
Shed type	36-bale rotary	Wintering (on)	On pasture, pasture silage, PKE

Table 2: Owl Farm Key Performance Indicators 2014-2019

	2014/15	2015/16	2016/17	2017/18	2018/19
Stocking rate (cows/ha)	2.76	2.83	2.9	2.82	2.76
MS per cow (kg)	445	396	421	402	417
MS per hectare production (kg)	1229	1122	1221	1136	1150
6-week in-calf rate (%)	74	73	72	64	74
Not-in-calf rate (%)	13	13	15	17	13
Pasture eaten (t DM/ha)	12.0	12.4	12.8	13.7	13.1
N fertiliser applied (kg/ha/year)	134	149	163	150	125
Production as a % of liveweight		80%	89%	85%	90%

Figure 2: Owl Farm Feed Eaten and Milk solids Production

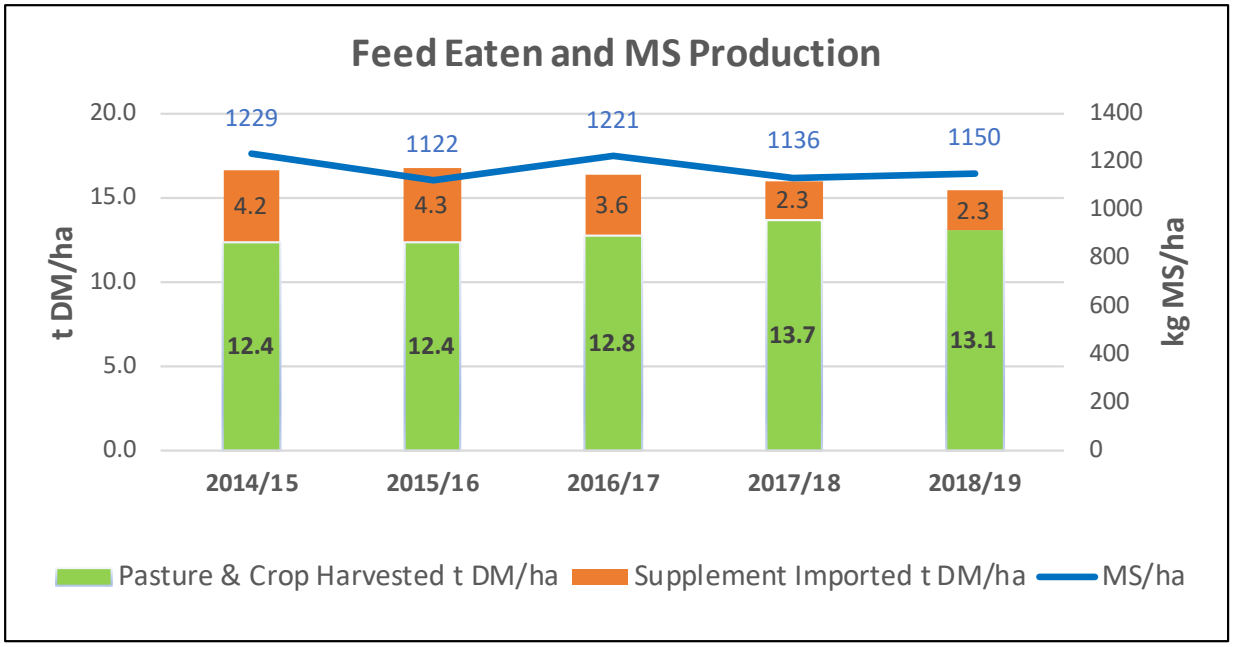


Figure 2 illustrates the trend away from imported supplement, increased pasture eaten/ha and declining MS/ha production.

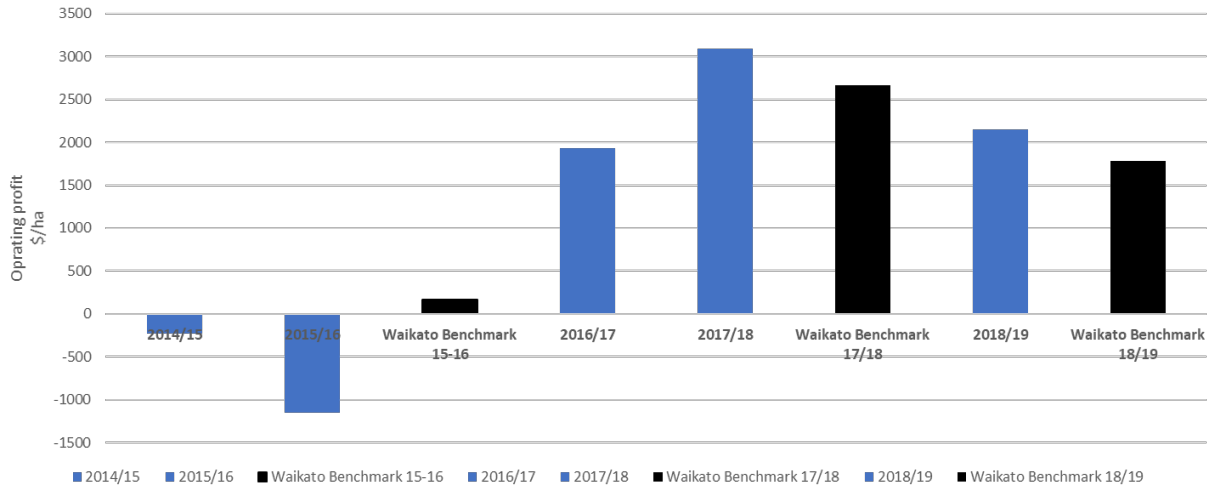
Financial Performance

Figure 3 details the operating profit and operating expenses over the last four seasons. Through DairyBase, profitability has been benchmarked against owner-operators in the Waikato region. There were 99 farms in this group in 2017/18 and 213 farms in 2015/16. Owl Farm's profitability/ha has changed from being average to below average, to exceeding the Waikato average through a reduction in operating expenses $/kg MS.

Owl Farm has gone from an operating loss of $-1156/ha in 2015/16 to a profit of $3090/ha in 2017/18. This compares to the benchmark group's operating profit that went from $171/ha in 2015/16 to $2661/ha in 2017/18.

Operating expenses have reduced from $5.39/kg MS in 2015/16 to $4.44/kg MS 2017/18. This compares with the benchmark group at $4.38/kg MS in 2015/16 and $5.16/kg MS in 2017/18.

Figure 3: Owl Farm: Operating Profit and Operating Expenses 2014-2019. (Source: DairyBase)



Five years of operating profit calculated at a standard milk price of $6/kg MS are presented in Figure 4, along with Milk solids production trends.

Figure 4

	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	% change year 1-5
Operating profit $/ha $6/kg MS	1456	1189	1807	2102	1922	+32%
Mean years 1-3, v years 4-5	1484			2012		+35.6%
Kg MS/ha	1229	1122	1221	1136	1150	-6
Kg MS/cow	445	396	421	402	417	-6

Environmental Performance

Overseer version 6.3.1 was used to look at changes in GHG emissions and N leaching over 5 years. The highlights are:

- A 15.4% decrease in total GHG emissions (from 14.3 t CO_2e/ha to 12.1 t CO_2e/ha).
- A 19.5% decrease in N leaching from 41 to 33 kg N /ha.
- Owl Farm has invested in a 1ha wetland area that removes 455 kg N/year from the whole farm system. This is 7% of the total N.

Table 1: Owl Farm N Leaching and Greenhouse Gas Emissions

	2014/15	**2015/16**	**2016/17**	**2017/18**	**2018/19**
Total N leached (kg/year)	7531	7414	7434	6314	5816
N Leached (kg N/ha/year)	41	40	41	35	33
N Surplus (kg N/ha) Overseer	204	187	193	189	176
N conversion efficiency (%)	28	26	27	25	29
GHG Total equivalent t CO2e/ha	14.3	12.5	13.6	12.5	12.1
Methane t CH4/ha	8.26	7.03	7.26	6.85	6.67
Nitrous oxide t N2O/ha	3.77	3.53	4.07	3.77	3.69
CO2 t/ha	2.25	1.90	2.30	1.90	1.76

Environmental Obligations for the Waikato Regional Council

This property is in the Waikato, at the 'Narrows sub-catchment' and the 'Middle Waikato Freshwater Management Unit.' Key dates for this property are:

- Register with council and provide a 'Nitrogen Reference Point' between 1 May 2020 and 30 November 2020
- Complete a Farm Environment Plan by 1 July 2026 and adhere to it
- Complete stock exclusion by 1 July 2026

The Nitrogen Reference point for the farm has been established at 46kg N/ha/year.

Waikato Regional Council will use the 'Nitrogen Reference Point' information to work out the 75th percentile value for nitrogen leaching from dairy farms in each Freshwater Management Unit (FMU). If Owl Farm is above this value, they will be required to reduce their losses to the 75th percentile, by July 2026.

If it is below the 75th percentile, they will be required to hold their discharge level at 46kg N/ha/year under the current rules.

Greenhouse Gas Emissions (GHG)

Owl Farm's reduction in greenhouse gases (GHG) so far has been a by-product of increasing profitability through efficiency gains in the farming operation, e.g., lower operating expenses $/kg MS, reducing total feed eaten and total N eaten.

Two areas have been considered to further reduce emissions by Owl Farm and have been examined through modelling. These are:

Option 1: Reduce cow numbers from 2.76 cows/ha to 2.6 cows/ha, growing all feed on the farm and not importing any supplements

Option 2: Increasing stocking rate to 3.0 cows/ha, importing 5–10% total feed and building infrastructure to stand cows off pasture and to feed supplements more efficiently. Increasing cow numbers and importing more supplement would, on their own, increase N-loss. However, with infrastructure where effluent/waste can be collected and returned to the land at a controlled rate, and at a suitable time to reduce N-loss to water and emissions.

In general, moving to housing while increasing the number of animals will have drivers that both increase emissions (increased numbers & emissions during storage of manures) and decrease emissions (avoiding direct deposition of dung and urine on pastures at times of high soil moisture).

Scenario 1: De-intensify

1. Maintain fertiliser nitrogen use at 150kg N/ha, maintaining current policy of using coated N with urease inhibitor (Sustain).
2. Remove 220 t PKE and 110 t DM of grass silage and reduce stocking rate to maintain comparative stocking rate for new feed supply comparable to the 2017-18 year of approx. 80-82kg LWT/t DM offered.
3. Continue growing 8% of farm in turnips for summer crop, and larger spring surpluses from lower stocking rate will increases summer silage on hand.
4. Increase effluent area by 8 hectares.
5. Improve the use of effluent solids by doubling the area they are applied to (6.4 ha to 12.8 ha). This lowers the N loading and reduces the need for N fertiliser on crops.

Scenario 2: Invest in Infrastructure

1. Maintain current levels of imported feed.
2. Install feed facilities (feed pad, silage bunkers and stand-off pad for 300 cows) to improve the potential for growing and feeding maize silage on the platform and reducing nutrient loss to waterways
3. In addition to 8% of farm sown in turnips, grow 8% of the farm in maize silage crops.
4. Increase stocking rate and stock numbers by 18 cows from base numbers in line with decreasing the comparative stocking rate and lifting per-cow performance.
5. Instal a feed-pad and silage bunkers to increase utilisation by 10% for all supplements fed on farm including 500+ t DM of homegrown pasture silage, plus 240 t DM of homegrown maize silage.
6. Use the standoff pad to avoid soil pugging in winter, overgrazing in summer and potentially create shade for cows in summer.
7. This option has cows standing off pasture for around 3 hours per day from January to September (6 hours stand-off in winter, and 1.5 hours in Aug-Sep) in addition to supplement feeding. During this

time dung and urine is not deposited on paddocks, resulting in reductions in N loss/ha, compared to the system without a stand-off pad.

8. Nutrients captured in the off-paddock facility can be spread onto maize crops, reducing fertiliser inputs.
9. Total fertiliser requirements are reduced due to additional nutrients captured on infrastructure and spread on an increased effluent area (8ha more under spray irrigation, plus solids to maize crop area).
10. The cost of infrastructure options is estimated at $750,000 including extra cows and Dairy Company shares.

Table 4: Future Options Compared with The Current System

	Base system 2017/18	Scenario 1 – Low Intensify	Scenario 2 - Infrastructure
Farm parameters			
Total area (ha)	180	180	180
Production (kg MS)	168,169	155,526	206,202
Peak cows	418	352	436
Nitrogen			
Total Farm N Loss (kg N)	6314	5444	5867
N Loss/ha (kg N/ha)	35	30	33
N Surplus/ha (kg N/ha)	189	151	179
Greenhouse gases			
Total GHG (tCO2e/ha/year)	12.5	10.9	12.7
Methane (tCO2e/ha/year)	6.8	6.0	7.9
N2O (tCO2e/ha/year)	3.8	3.4	3.6
CO2 (tCO2e/ha/year)	1.9	1.5	1.2
Profitability			
Operating profit ($/ha)	2144	2595	3022
Change from current system			
N leaching (%)		-14%	-7%
GHG losses (%)		-13%	+2%
Profitability (%)		+21%	+41%

Scenario 1: Operating profit increases from $2144/ha to $2595/ha (+21%) due to lower costs as less feed purchased.

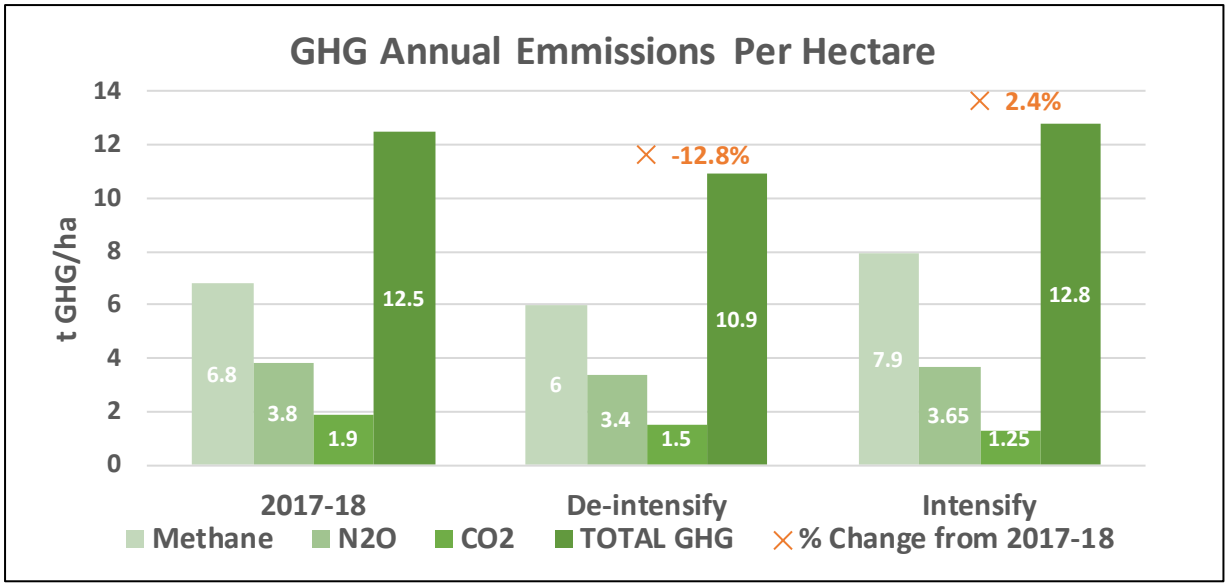
Scenario 2: Operating profit increases from $2144/ha to $3022/ha (+ 41%). Operating profit is calculated after depreciation on the infrastructure investment has been accounted for at $0.40/kg MS.

Profit increases as the income from extra milkolids produced is greater than the increase in costs. The increase in supplement utilisation of 10% of the existing 700t DM of supplement results in more feed eaten at no extra feed cost. There were some small cost savings in fertiliser spend with the increase in the effluent area.

However, operating profit does not include the interest cost on the investment. If the cost of interest to borrow the $750,000 at 7% interest is accounted for, profit is reduced by $292 compared to 2017/18 and Scenario 1 (de-intensifcation). Profit is still higher at $2730/ha, a 27% increase on the current system.

Neither of the options signifcantly reduces N leaching. De-intensification (Option 1) reduces N leaching from the current system (2017-18) of 35kg N/ha to 30kg N/ha. The stand-off area and feed pads do reduce some N leaching but by very little, and this is largely due to the reduction in the N surplus from 189kg N/ha to 179kg N/ha due to the diet having a lower average N content (maize silage, which is a low nitrogen feed).

Figure 3: Owl Farm Mitigation Assessment



Conclusions

De-intensifying by removing a further 330 t DM of imported supplement will lead to further reductions in methane, and N leaching (reduced N surplus). Farm profit is predicted to improve, providing expenditure can be reduced to offset lower production. However, there will be a considerable reduction in revenue and investment in the rural sector from the farm due to this scenario.

Intensifying by adding infrastructure allowed for a 10% increase in utilisation of supplements, increasing feed eaten, and allowed some more profitable options for feed production and utilisation to be explored. The increase in milk production from an increase in total feed eaten increased methane production and total GHGs are predicted to increase by 2.4% over 2017-18 emissions.

Summary

Looking to increase profitability, Owl Farm has over the past five years transitioned away from a farm system that relied on purchased maize silage and PKE, towards a system more reliant on pasture and other feed grown on the milking platform. While succeeding in increasing profit, Owl Farm has also reduced its total CO_2 e emissions by 15.4%, and decreased N leaching from 41 to 33kg N/ha (19%). This has been achieved by reducing feed eaten and reducing the farm's N Surplus.

The options investigated show that:

1. De-intensification can result in further reduction of GHG and N leaching while increasing profit providing pasture eaten can be maintained with a lower stocking rate and cost reductions achieved. As the farm becomes more efficient with growing and utilising home-grown feed, it becomes more difficult to reduce emissions without compromising profit. There are also affects outside the farm-gate.
2. Intensification and investing in infrastructure show that profit can be increased by 41% before interest on the $750,000 investment, and by 27% accounting for the interest on the investment. However, this option increases Owl Farm's GHG emissions and is not in line with their goal of reducing environmental footprint. It could also be investment in part, in sunk capital (infrastructure facilities) if in the future the farm must reduce emissions further.