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Practical Solutions for High Rainfall Dairy Effluent Systems

Prepared for Our Land and Water Contestable Fund

Report prepared by
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DOCUMENT QUALITY ASSURANCE

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1.0 EXECUTIVE SUMMARY

The purpose of this project was to develop and pilot practical solutions for high rainfall dairy effluent systems with the movement away from discharge of treated farm dairy effluent to water by the Taranaki Regional Council, and the requirement of no discharge to water by the 1st of June 2025 for Fonterra suppliers.

Four high altitude/rainfall case study farms were selected and analysed:

» A paddock level soil survey of each farm to accurately map soil type, contour, and effluent application risk.

» An analysis of their OverseerFM and Farmax for their current farm dairy effluent system.

» A new farm dairy effluent system designed using the Dairy Effluent Storage Calculator to meet the Fonterra 1st of June 2025 requirement.

» OverseerFM and Farmax analysis with proposed effluent system upgrades to assess the impact on nutrient loss and greenhouse gas emissions, and farm system profitability.

The analysis showed that farm dairy effluent systems can be designed for these farms that result in sufficient storage and nil discharge to water. However, these systems require a significant amount of capital expenditure, up to two times the cost of farm dairy effluent systems in lower rainfall and altitude areas. The cost of the capital expenditure resulted in a 12% - 22% decrease in cash operating surplus across the four case study farms. This reduces the farm businesses reserves for debt repayment, drawings, CAPEX, tax, and interest payments.

The proposed effluent system upgrades resulted in a decrease in nitrogen leaching (by 3% - 15%), reduced phosphorus losses (0 - 40%) and reductions in methane (0 - 7%), nitrous oxide (1% - 10%) and carbon dioxide (0 - 14%) emission across the case study farms. Overall water use was also reduced on each farm through green water recycling.

Whilst this project demonstrates that farm dairy effluent systems can be designed to eliminate discharge to water and that there is a positive impact on environmental KPI's, a significant cost is required. For some farms, the high cost will be prohibitive due to any of the following:

» Farm debt levels at a level where no additional borrowing can be obtained.

» The farm business cannot support the additional interest cost (negative cash operating surplus).

» The farm is not of size or scale to justify the level of capital expense or its interest cost.

Farmers who are impacted by the required farm dairy effluent management changes, will need to undertake thorough due diligence, including a full farm system review and, in some cases, an alternative land-use study to assess if farm system changes are required, or if there are alternative land uses to dairying. There is not a one size fits all approach, and the decision on how each farm proceeds (or not) will be unique to their individual situation and goals.

2.0 BACKGROUND

Dairy farms in close proximity to Mount Taranaki have a unique set of challenges. The relatively high altitude of these dairy farms results in high rainfall, often over 2500 mm per annum. The high rainfall, combined with high-risk soils, usually due to slope, combine to create very challenging environments to manage dairy effluent in a sustainable manner.

Historically the Taranaki Regional Council and the main milk processor, Fonterra, have permitted effluent discharge to water (after pond treatment). However, the council is moving away from approving such consents, and more crucially, Fonterra has recently announced that by 1 June 2025 they will no longer collect milk from farms that still discharge to water. This creates an urgent need to develop and implement long term effluent management solutions if these farms are to continue dairy farming. If immediate solutions to managing dairy effluent in these high rainfall/high risk soils environments are not found, there are numerous dairy farms in close proximity to Mount Taranaki that are at imminent risk of becoming non-compliant and potentially having to cease dairy supply.

The two greatest FDE (farm dairy effluent) system inputs are cow yard wash water use and rainfall. The greatest portion of wash water is used on the cow yard (approx. 70%). Rainwater on the cow yard and effluent storage facility in these high rainfall areas add significant volume. The High Altitude Dairy Effluent Solutions (HADES) group, funded by the Taranaki Catchment Communities (TCC), commissioned a review of technology options. This review was completed by Element environmental consultants in December 2021. The review, at a high level, outlined a range of solutions to this problem. The proposed solutions included good management practice and efficiency, water treatment at the dairy shed and treatment post application to land.

The report recommended *"the next practical steps include: gaining an understanding of how much water saving techniques will shift the dial on a range of existing system types in the HADES area, investigate the regulatory and policy context to ensure HADES farmers can meet long term environmental goals, investigate some of the more suitable water treatment systems and their applicability to HADES, work with regional council and other stakeholders to decide whether a HADES area soil risk assessment is an appropriate step, and investigate the viability of edge of field tools as an option in the HADES area for run-off water treatment."*

This project picks up on the final recommendation to **develop and pilot practical solutions for high rainfall dairy effluent systems**. The proposal was to research the base data required and then pilot some initial concepts. Although this proposal produced an output in its own right, it also provided recommendations on further research required.

3.0 OBJECTIVES

The objectives for the project were:

(a) Obtain accurate, localised soil, contour, and climate data. The data will show how the soils and slopes are reacting to rainfall and provide available irrigation days per year that will allow for development of fit-for-purpose solutions.

(b) Complete high-level fit for purpose effluent management system designs in line with the data.

(c) Disseminate the results to all stakeholders and affected parties.

(d) Provide recommendation for future research or building of infrastructure.

4.0 METHODOLOGY

The methodology for the project involved:

(a) Select four case study farms with differing characteristics surrounding Mount Taranaki (North, East, South and West).

(b) For each of the properties, accurately map the soil type contour, and soil infiltration rates.

(c) Complete high-level fit for purpose effluent management system designs in line with the data analysed.

(d) Analyse the likely impact of nutrient management, capital expenditure and impacts on farm system.

(e) Compilation of reports and extension material.

(f) Undertake 2 - 3 workshops/networking events to ensure the information is disseminated as widely as possible.

5.0 CASE STUDY FARMS

Four case study farms from around the mountain (North, South, East, West) classified as being high altitude and directly impacted by the requirement for no farm dairy effluent discharge to water were approached and agreed to participate in the project.

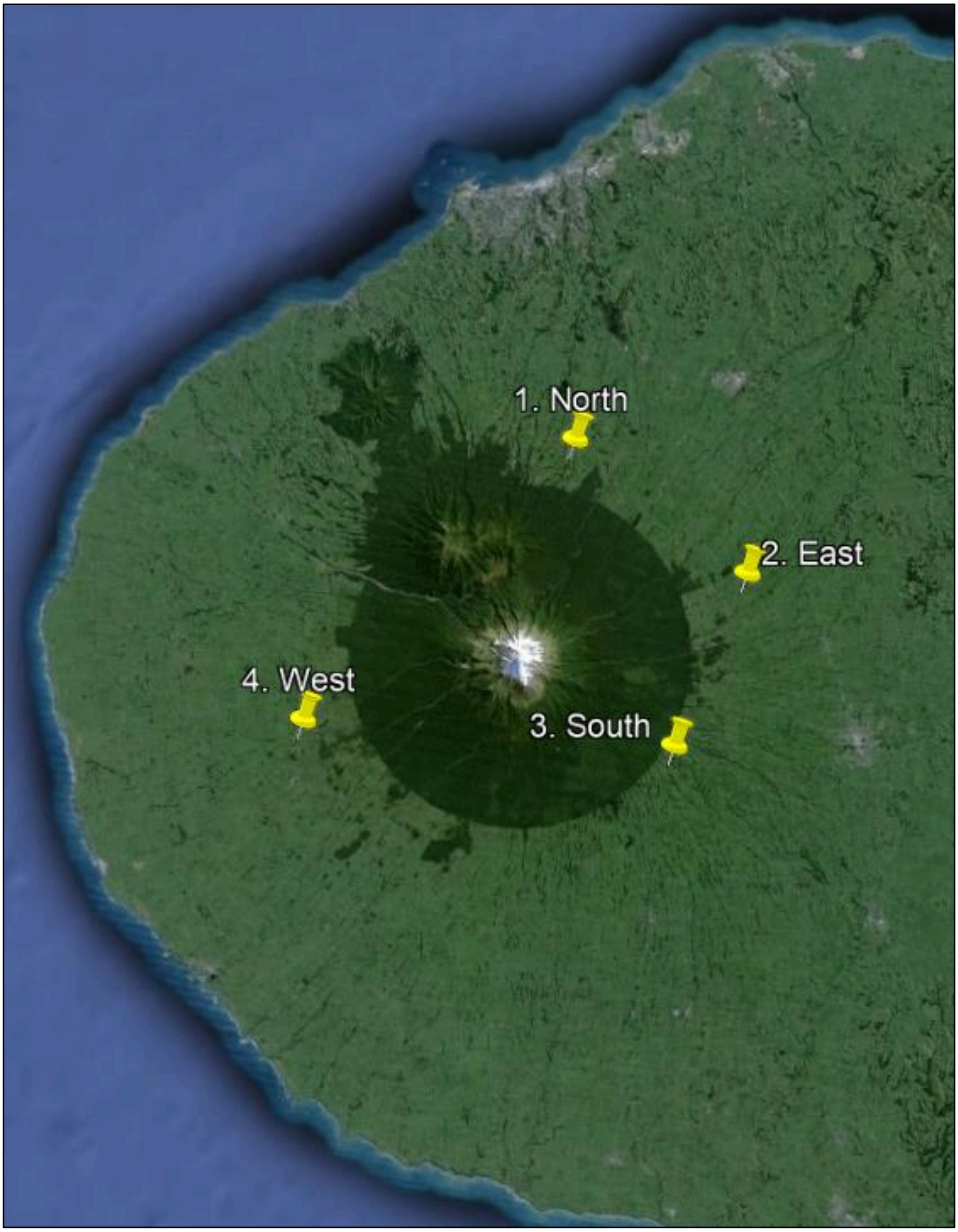

Figure 1: Case Study Farm Locations

5.1 Whole Farm System Analysis

A whole farm system model was created in Overseer FM and Farmax for each case study farm using information provided based on the 2022/23 season (Table 1). The primary purpose was to compare the productivity, profitability, and environmental impact (nutrient loss, water quality, GHG) of the four case study farms current farm and effluent system to the proposed effluent system upgrades.

Table 1: Physical parameters for each case study farm in the base Overseer & Farmax models

		1. North	2. East	3. South	4. West
Effective Farm Area	ha	230	105	158	175
Contour		Rolling	Rolling	Rolling	Rolling
Stocking Rate per ha		2.2	2.6	2.3	2.2
Area FDE Applied	ha	N/A	16	N/A	22
Farm Infrastructure		Covered wintering pad/shelter	Uncovered feed pad	Covered wintering pad/shelter	Covered wintering pad/shelter
Cows Wintered (1 June)		519	275	370	399
Cows Wintered Off		0	120	0	0
Peak Cows Milked		515	270	360	391
Total Production	kg MS	202,606	78,123	150,521	116,954
Production per ha	kg MS	881	744	953	608
Production per cow	kg MS	393	295	418	299
Forage Crop		N/A	N/A	Summer Forage Rape	N/A
Forage Crop Area	ha	N/A	N/A	8	N/A
Forage Crop Yield	t DM/ha	N/A	N/A	11	N/A
Total Feed Harvested on Farm	t DM	120	0	210	88
Total Feed Imported off Farm	t DM	738	318	162	370
Soil Type		Volcanic Allophanic, Moderately Well Drained (71%). Volcanic Allophanic, Poorly Drained (18%). Pumice, Moderately Well Drained (11%)	Volcanic Allophanic, Moderately Well Drained (41%). Volcanic Allophanic, Poorly Drained (31%). Volcanic Allophanic, Imperfectly Drained (28%)	Volcanic Allophanic, Well Drained (100%)	Volcanic Allophanic, Imperfectly Drained (80%). Volcanic Allophanic, Poorly Drained (20%).

Assumptions used in the Overseer FM and Farmax to standardise the four case study whole farm system models:

- Soil test results at optimum for pasture production on volcanic Allophanic soils.
- Nitrogen applied as urea from Ravensdown.
- Fertiliser applied as Ravensdown 20% Potash Super to maintain soil test levels.
- PKE used as concentrate fed where applicable.

All other physical parameters as per each case study farm management practices, policies, and inputs.

5.2 Effluent System Designs

Storage calculations were completed using the Dairy Effluent Storage Calculator. Designs are based on information gathered on farm together with our experience with achievable water use reduction via green wash.

Please note, calculations will need to be completed again if any of the inputted practices/parameters change. Storage calculations use higher peak cows milked than actually milked on farm.

Each case study farm has had a weather station together with two soil moisture sites strategically installed on the most predominant soil types. These monitoring solutions calculate soil water deficit to assist with effluent irrigation management and will provide data over time of the actual available irrigation days. The monitoring sites will also be used for effluent proof of placement via GPS tracking and failsafe via wheel speed and pressure sensors. The effluent area will be geofenced to ensure the effluent cannot be spread in high-risk zones where discharge to water may occur. The monitoring solutions will reduce labour requirement as irrigators can be started and stopped from the user's smart phone, computer or from a switch on the irrigator itself.

Soil risk on all four properties has been assessed and mapped together with slope. These reports and maps are provided as separate documents.

All four case study farms storage calculations are based on stormwater diversion being used on the farm dairy yard throughout the season and when the cows are dried off. Shed roof water being diverted away from the effluent system and three days emergency storage has also been factored into the calculation.

Table 2 below shows the summary of the current dairy effluent system and the proposed dairy effluent system for the four case study farms.

Table 2: Summary of current dairy effluent system and proposed dairy effluent system

		1. North	2. East	3. South	4. West
Average Rainfall (Overseer)	mm	6,991	3,139	3,402	2,492
Current FDE System		Discharge to water via pond treatment	Dual Consent. Discharge to water + low rate land application via sprinklers	Discharge to water via pond treatment	Dual Consent. Discharge to water + high rate land application via travelling irrigator
Current Area FDE Applied	ha	0	16	0	22
Proposed FDE System		Discharge to land via low rate travelling rain guns	Discharge to land via low rate travelling rain guns	Discharge to land via a low rate travelling rain gun	Discharge to land via low rate travelling rain guns
Proposed FDE Storage		New - uncovered, lined pond	Existing - uncovered, unlined pond	New - uncovered, lined pond	New - uncovered, lined pond
Proposed Area FDE Applied	ha	20	19	35	30
Irrigation Volume per day	m^3/day	200	200	100	160
Application Depth	mm	10	6	10	7
Current – Green water Recycling		No	No	No	No
Current Dairy Shed Water Use	m^3/day	35.0	60.0	23.0	20.0
Proposed – Green water Recycling		Yes - Cow yard	Yes - Cow yard & feed pad	Yes - Cow yard	Yes - Cow yard
Proposed Dairy Shed Water Use	m^3/day	20	15	15	15
Soil Type Risk - Effluent Area		Low	Low	Low	High
Available Irrigation Days		203	263.	241.	126.
Actual Peak Cows Milked		515	270	360	391
Peak Cows Milked in DESC		550	300	450	500

Proposed farm dairy effluent systems are 100% land application with no discharge to water for each of the four case study farms. To achieve this, the North and South farms have defined new effluent application area, whilst the East and West farms have an increase in area that farm dairy effluent is applied.

Green water recycling is proposed on all farms which results in a reduction in dairy shed water use.

5.2.1 North Farm

The calculation is based on milking a peak herd size of 550 cows split over two herds. Herds are milked once-a-day (OAD) for the month of August then twice-a-day (TAD) until 1 December. One herd is then milked OAD until dry off while the other herd is milked TAD until 1 May and then OAD until dry off.

Lower depth at lower flow rates were considered but were deemed to be too labour intensive for little to no gain, compared to larger volumes at slightly greater depth.

5.2.1.1 Description

The most practical location for a fit for purpose dairy effluent storage solution is in the same location as the existing three pond treatment system. The alternative is to install a pumping station to transfer effluent to a new site or to directionally drill 220 m under the dairy shed to a new site. The alternative options have been ruled out due to risk and cost.

Given the significant rainfall and risk associated with intense rain events, achieving gravity to storage is essential. This way, capacity can be always kept available for storm events or mechanical failure.

Multiple different storage solutions were considered. However, given the need for gravity, above ground tanks and bladders were ruled out as fit for purpose solutions as they will need to be pumped into on this site. An in-ground lined storage pond with option to cover has been concluded as the best solution.

Capital and operating costs have been considered. The most cost-effective solution is an un-covered lined pond with high volume irrigation system. However, this does add effluent volume and if the farm would like to reduce volume further, the pond and or catchment areas/yard can be covered.

5.2.1.2 Rainwater diversion, stone trap, and solids storage

There is an existing stone trap solution at the end of the cow yard. It is proposed that some minor improvements are made at the stone trap, and a user-friendly rainwater diversion system is installed. The new design allows for a secondary stone trap, solids storage bunker and containment apron.

5.2.1.3 Pond Construction

It is proposed that a new 2,532 m^3 lined storage pond is constructed at the same site as the existing ponds. The old ponds are to be fully emptied, de-sludged, and de-contaminated. A ground water drainage system is to be constructed to remove any ground water from the construction site via gravity. The new pond will then be constructed. Allowances will be made to add a floating cover in the future.

5.2.1.4 Green Water Recycling
Green water recycling on the cow yard is required to reduce effluent volume. A green water pump will draw off the top of the effluent pond and will wash the yard via a high volume/low pressure flood wash system.

5.2.1.5 Effluent Irrigation System
The key challenge on this farm is setbacks from water courses and slope. An irrigator solution is required that has an adjustable wetted diameter and a low rate of application. To achieve the required irrigation volume of up to 200 m^3/day without significant irrigation hours, a large irrigation pumping and pipeline solution has been specified. The required hydraulic operating flow is 40 - 50 m^3/hour at up to 11.2 bar operating pressure. To achieve this, two low rate travelling rain guns have been recommended. These will have capacity to run both at the same time. An infield irrigation system has been designed utilising a 150 mm PN16 PVC pipeline and combination of 110 mm and 75 mm PN12.5 and PN8 polyethylene pipelines.

5.2.2 East Farm
Increased irrigation capacity is needed to apply required volumes over the available irrigation days. The calculation is based on milking a peak herd size of 300 cows. The cows are milked TAD. The full herd is milked until the 1st of May with half the herd being milked the remaining of May.

Lower depth at lower flow rates were considered but were deemed to be too labour intensive for little to no gain compared to larger volumes at slightly greater depth.

Storm water from the feed pad will not be diverted.

5.2.2.1 Description
The calculation demonstrates that the existing first pond may provide sufficient storage capacity. Given this, the design is based on using the existing pond and focusing more on reduced effluent volume and increased effluent irrigation capacity.

There are some concerns around how well the soil will drain after rain events due to hard pans around 0.6 m - 1.0 m deep holding “perched” water and not allowing the soils to drain. These areas have been avoided or classified as high risk but may need further monitoring in the future.

5.2.2.2 Rainwater diversion, stone trap, and solids storage
It is proposed that some minor improvements are made at the stone trap and user-friendly rainwater diversion system is installed. The new design allows for a secondary stone trap, solids storage bunker and containment apron.

5.2.2.3 Pond Construction
The old first pond is to be fully emptied and de-sludged. Taranaki Regional Council (TRC) will need to confirm whether the existing pond is suitable to be used. When the pond is emptied it must be checked for ground water intrusion. If this is an issue, a ground water drainage system will be required, and a pond lining solution installed.

5.2.2.4 Power Supply

The existing power supply is fit for purpose. However, a new electrical control board will be required to operate the new irrigation system.

5.2.2.5 Green Water Recycling

Green water recycling on the cow yard is required to reduce effluent volume. A green water pump will draw off the top of the effluent pond and will wash the round yard via a high volume/low pressure gate wash system. The existing feed pad flood wash system will be used for recycling green water on the feed pad.

5.2.2.6 Effluent Irrigation System

The key challenge on this farm is setbacks from water courses and slope. An irrigator solution is required that has an adjustable wetted diameter and a low rate of application. To achieve the required irrigation volume of up to 200 m^3/day without significant irrigation hours, a large irrigation pumping and pipeline solution has been specified. The required hydraulic operating flow is 40 - 50 m^3/hour at up to 8 bar operating pressure. To achieve this, two low rate travelling rain guns have been recommended. These will have capacity to run both at the same time. An infield irrigation system has been designed utilising the existing 100 mm PN9 PVC pipeline and combination of new 110 mm and 75 mm PN12.5 and PN8 polyethylene pipelines.

The application depth of as low as 6 mm will significantly increase labour requirement. To reduce this, a larger storage pond is required to defer irrigation to a time when application depths can be increased. A cover on the pond and or feed pad will also significantly reduce volume and irrigation hours.

5.2.3 South Farm

The calculation is based on milking a peak herd size of 450 cows TAD.

5.2.3.1 Description

The most practical location for a fit for purpose dairy effluent storage solution is in the same location as the existing three pond treatment system.

Given the significant rainfall and risk associated with intense rain events, achieving gravity to storage is essential. This way, capacity can be always kept available for storm events or mechanical failure.

Multiple different storage solutions were considered. However, given the need for gravity, above ground tanks and bladders were ruled out as fit for purpose solutions as they will need to be pumped into on this site. An in-ground lined storage pond with option to cover has been concluded as the best solution.

Capital and operating costs have been considered. The most cost-effective solution is an un-covered lined pond with high volume irrigation system. However, this does add effluent volume and if the farm would like to reduce volume further, the pond and or catchment areas/yard can be covered.

5.2.3.2 Rainwater diversion, stone trap, and solids storage

It is proposed that some minor improvements are made at the stone trap and a user-friendly rainwater diversion system is installed. The new design allows for a secondary stone trap, solids storage bunker and containment apron.

5.2.3.3 Pond Construction

It is proposed that a new 4,574 m^3 lined storage pond is constructed at the same site as the existing ponds. The old ponds are to be fully emptied, de-sludged, and de-contaminated. A ground water drainage system is to be constructed to remove any ground water from the construction site via gravity. The new pond will then be constructed. Allowances will be made to add a floating cover in the future. It is noted that this pond is well over sized, and a smaller pond can be built if desired.

5.2.3.4 Power Supply

A new power supply from the dairy shed down to the new effluent pond is required. Approximately 4 hours of irrigation is required per available irrigation day. Therefore, if the power supply to the dairy shed is not sufficient, the effluent system can operate outside of milking times.

5.2.3.5 Green Water Recycling

Green water recycling on the cow yard is required to reduce effluent volume. A green water pump will draw off the top of the effluent pond and will wash the round yard via a high volume/low pressure gate wash system.

5.2.3.6 Effluent Irrigation System

The key challenge on this farm is setbacks from water courses and slope. An irrigator solution is required that has an adjustable wetted diameter and a low rate of application. To achieve the required irrigation volume of up to 100 m^3/day without significant irrigation hours, an irrigation pumping and pipeline solution has been specified. The required hydraulic operating flow is 20 m^3/hour at up to 12 bar operating pressure. To achieve this, a low rate travelling rain gun has been recommended. An infield irrigation system has been designed utilising a combination of new 110 mm and 75 mm PN12.5 and PN8 polyethylene pipelines.

5.2.4 West Farm

The calculation is based on milking a peak herd size of 500 cows TAD.

Lower depth at lower flow rates were considered but were deemed to be too labour intensive for little to no gain compared to larger volumes at slightly greater depth.

5.2.4.1 Description

The most practical location for a fit for purpose dairy effluent storage solution is in the same location as the existing two pond treatment system.

Given the significant rainfall and risk associated with intense rain events, achieving gravity to storage essential. This way, capacity can be always kept available for storm events or mechanical failure.

Multiple different storage solutions were considered. However, given the need for gravity, above ground tanks and bladders were ruled out as fit for purpose solutions as they will need to be pumped in to, on this site. An in-ground lined storage pond with option to cover has been concluded as the best solution.

Capital and operating costs have been considered. The most cost-effective solution is an un-covered lined pond with high volume irrigation system. However, this does add effluent volume and if the farm would like to reduce volume further, the pond and or catchment areas/yard can be covered.

5.2.4.2 Rainwater diversion, stone trap, and solids storage

It is proposed that some minor improvements are made at the stone trap and user-friendly rainwater diversion system is installed. The new design allows for a secondary stone trap, solids storage bunker and containment apron.

5.2.4.3 Pond Construction

It is proposed that a new 5,872 m^3 lined storage pond is constructed at the same site as the existing ponds. The old ponds are to be fully emptied, de-sludged, and de-contaminated. A ground water drainage system is to be constructed to remove any ground water from the construction site via gravity. The new pond will then be constructed. Allowances will be made to add a floating cover in the future.

5.2.4.4 Power Supply

A new power supply from the dairy shed down to the new effluent pond is required. Approximately 4 hours of irrigation is required per available irrigation day. Therefore, if the power supply to the dairy shed is not sufficient, the effluent system can operate outside of milking times.

5.2.4.5 Green Water Recycling

Green water recycling on the cow yard is required to reduce effluent volume. A green water pump will draw off the top of the effluent pond and will wash the yard via a high volume/low pressure gate wash system.

5.2.4.6 Effluent Irrigation System

The key challenge on this farm is soil types impeded drainage together with setbacks from water courses and slope. An irrigator solution is required that has an adjustable wetted diameter and a low rate of application. To achieve the required irrigation volume of up to 170 m^3/day without significant irrigation hours, a large irrigation pumping and pipeline solution has been specified. The required hydraulic operating flow is 40 - 50 m^3/hour at up to 8 bar operating pressure. To achieve this, two low rate travelling rain guns have been recommended. These will have capacity to run both at the same time. An infield irrigation system has been designed utilising a 100 mm PN10 PVC pipeline and combination of 90 mm and 75 mm PN12.5 and PN8 polyethylene pipelines.

6.0 RESULTS

6.1 Whole Farm System Analysis – Effluent System Upgrades

The proposed effluent system upgrades as above were modelled through Overseer FM and Farmax. Physical parameters were kept the same as the base model. Fertiliser (incl. nitrogen) input and farm dairy effluent management was adjusted. The impact of these adjustments were compared to the base model for each farm, and productivity, profitability, nutrient losses, and GHG emissions analysed.

6.2 Overseer – Environmental

Whole farm environmental results are summarised in Table 3 below.

Table 3: Overseer results - effluent system upgrades

Overseer Results									
		1. North				2. East			
		Before	After	Change	% Change	Before	After	Change	% Change
Blocks	Non-Effluent Area (ha)	230	210	-20		89	86	-3	
	Effluent Area (ha)	0	20	20		16	19	3	
	Total Area (ha)	230	230			105	105		
Nitrogen	Loss/ha (kg/ha)	72	65	-7	-10%	58	54	-4	-7%
	NCE %	29	29	0	0%	24	25	1	4%
Phosphorus	Loss/ha (kg/ha)	4	3	-1	-30%	2	2	0	-5%
GHG	Methane (CO_2-e t/y)	1,639	1,524	-115	-7%	640	640	0	0%
	N_2O (CO_2-e t/y)	478	439	-39	-8%	165	160	-5	-3%
	CO_2 (CO_2-e t/y)	1,271	1,268	-4	0%	195	189	-6	-3%
		3. South				4. West			
		Before	After	Change	% Change	Before	After	Change	% Change
Blocks	Non-Effluent Area (ha)	158	123	-35		153	145	-8	
	Effluent Area (ha)	0	35	35		22	30	8	
	Total Area (ha)	158	158			175	175		
Nitrogen	Loss/ha (kg/ha)	68	58	-10	-15%	37	36	-1	-3%
	NCE %	33	34	1	3%	29	29	0	0%
Phosphorus	Loss/ha (kg/ha)	3	2	-1	-40%	2	2	0	0%
GHG	Methane (CO_2-e t/y)	1,156	1,079	-76	-7%	839	839	0	0%
	N_2O (CO_2-e t/y)	318	286	-32	-10%	238	236	-3	-1%
	CO_2 (CO_2-e t/y)	187	161	-26	-14%	183	179	-4	-2%

6.2.1 Nitrogen Loss

All four case study farms show a reduction in nitrogen loss with the modelled effluent system upgrades. The South farm having the highest nitrogen loss reduction of 15% (10 kgN/ha/year) and the West farm the lowest reduction of 3% (1 kgN/ha/year). The main driver of the reductions is the proposed effluent systems are land application, no discharge to water, therefore there is no nitrogen loss from direct pond discharge. Less nitrogen fertiliser is applied over the whole farm as effluent is the source of nitrogen on the effluent area which is a factor in the reduction in nitrogen loss.

The North and South farms current effluent systems are 100% discharge to water, no land application whilst the East and West farms are dual discharge to land and discharge to water. The North and South farms have a greater nitrogen loss from direct pond discharge; thus, these two case study farms have the highest modelled nitrogen loss reduction.

6.2.2 *Phosphorus Loss*

Modelled phosphorus losses are reduced across all case study farms with the proposed effluent system upgrades ranging from 0% - 40% (0 - 1 kgP/ha/year). Again, these reductions are driven by less total phosphorus applied as fertiliser with effluent being the source of phosphorus on the effluent area. The North and South farms see the largest reduction in phosphorus losses due to no direct pond discharge.

6.2.3 *Greenhouse Gases*

Both the North and South farms have a modelled reduction in methane of 7% as a result of applied effluent to pasture and not discharging to water. The main source of methane emissions is enteric (livestock) on all the case study farms. No changes were made to livestock numbers, management, or properties in the proposed effluent system models. Therefore, the reduction in methane emissions is directly related to the effluent system. The East and West farm were already applying effluent to land resulting in no change to methane emissions.

All four case farms show a reduction in nitrous oxide emissions with the modelled effluent system upgrades. Again, the North and South farm have the highest reduction of 8% and 7% respectively due to the combination of no discharge to water and reduced nitrogen use. The East and West farms have lower nitrous oxide reductions of 3% and 1%.

Carbon dioxide emissions are reduced by 0% - 14% across the case study farms. This reduction is driven by the decrease fertiliser and nitrogen applied.

6.3 Farmax Results - Financial

Whole farm financial results are summarised in Table 4 below.

Table 4: Farmax results - effluent system upgrades

		1. North	2. East	3. South	4. West
Milk Price	$/kg MS	$7.70	$7.70	$7.70	$7.70
Total Farm Revenue		$1,642,930	$634,559	$1,215,827	$954,407
Farm Revenue per ha	$/ha	$7,143	$6,043	$7,695	$5,454
Farm Revenue per kg MS	$/kg MS	$8.11	$8.12	$8.08	$8.16
Total Farm Working Expenses		$1,401,307	$588,344	$840,697	$761,142
Farm Working Expenses per ha	$/ha	$6,093	$5,603	$5,321	$4,439
Farm Working Expenses per kg MS	$/kg MS	$6.92	$7.53	$5.59	$6.51
Cash Surplus		$241,623	$46,215	$375,130	$193,265
Cash Surplus per ha	$/ha	$1,050	$440	$2,374	$1,015
Cash Surplus per kg MS	$/kg MS	$1.19	$0.59	$2.49	$1.65
Liabilities per kg MS	$/kg MS	$20.00	$20.00	$20.00	$20.00
Interest Rate	%	5%	5%	5%	5%
Total Interest		$202,606	$78,123	$150,521	$116,954
Cash Operating Surplus		$39,017	-$31,908	$224,609	$76,311
CAPEX - Effluent System Upgrades		$492,700	$316,200	$400,000	$510,700
Total Interest		$227,241	$93,933	$170,521	$142,489
Cash Operating Surplus		$14,382	-$47,718	$204,609	$50,776
Difference in Cash Operating Surplus		-$24,635	-$15,810	-$20,000	-$25,535
% Change		-12%	-20%	-13%	-22%

6.3.1 Farm Revenue

Milk price standardised at $7.70/kgMS. Farm revenue varies across the four case study farms as a result of total production and stock income. Total farm revenue remains unchanged in the modelled effluent system upgrades as no changes were made to physical parameters.

6.3.2 Farm Working Expenses

Farm working expenses per kgMS is varied across the four case study farms. The East farm has the lowest total farm working expenses, and also has the lowest production resulting in the highest farm working expenses per kgMS.

6.3.3 Cash Surplus

There is a large variance in cash surplus (total revenue less farm working expenses) across the four farms. All cash surpluses are positive. The East farm has the lowest cash surplus whilst the South farm has the highest cash surplus. Cash surplus is used to pay interest, principal, drawings, tax, and CAPEX.

6.3.4 Cash Operating Surplus

Liabilities per kgMS ($20/kgMS) and interest rate (5%) were standardised across the four farms and both models to calculate total interest cost for each farm and therefore cash operating surplus. The East farm has a negative cash operating surplus whilst the other three have positive cash operating surpluses.

6.3.5 CAPEX – Effluent System Upgrades

The capital cost of the proposed effluent system upgrades for each of the case study farms has been assumed to be 100% borrowed, adding to total farm liabilities. As a result of the increased liabilities, total interest cost increases, which is to be expected.

6.3.6 Cash Operating Surplus

The increased interest cost of the proposed effluent system upgrades results in a 12% - 22% reduction in cash operating surplus. Again, for the East farm it is negative, for the other three farms, positive, albeit reduced.

7.0 DISCUSSION

As the analysis shows, the proposed effluent system upgrades result in a reduction in nitrogen and phosphorus loss and greenhouse gas emissions. Proposed green water recycling sees a reduction in water use across the four case study farms. Overall, the farms can meet Fonterra's directive of no farm dairy effluent discharging to water as well as the TRC move away from water discharge.

There is a significant capital cost to the upgrades, significantly in excess of lower altitude (rainfall) dairy effluent system upgrades. The extra interest cost has a negative impact on cash operating surplus and reduces the farms reserves for debt repayment, drawings, tax, and CAPEX. In the East farm's case (with assumed debt levels), already negative cash operating surpluses are further increased with the upgrades making the business even more unsustainable.

The analysis shows that high cash operating surpluses are needed to fund the cost of the capital spend. This will vary farm by farm and dependant on debt levels and interest rates. However, it is clear that having a high cash surplus (maximising revenue and minimising costs) result in the businesses being able to support the additional CAPEX (therefore interest) required and remain profitable, as is the case for the North, South, and West farms.

Further work is required to assess whether farm system changes can reduce the requirements of required effluent upgrades and therefore the capital cost, as well as improving farm profitability so the farm business can support itself as well as the additional borrowing.

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