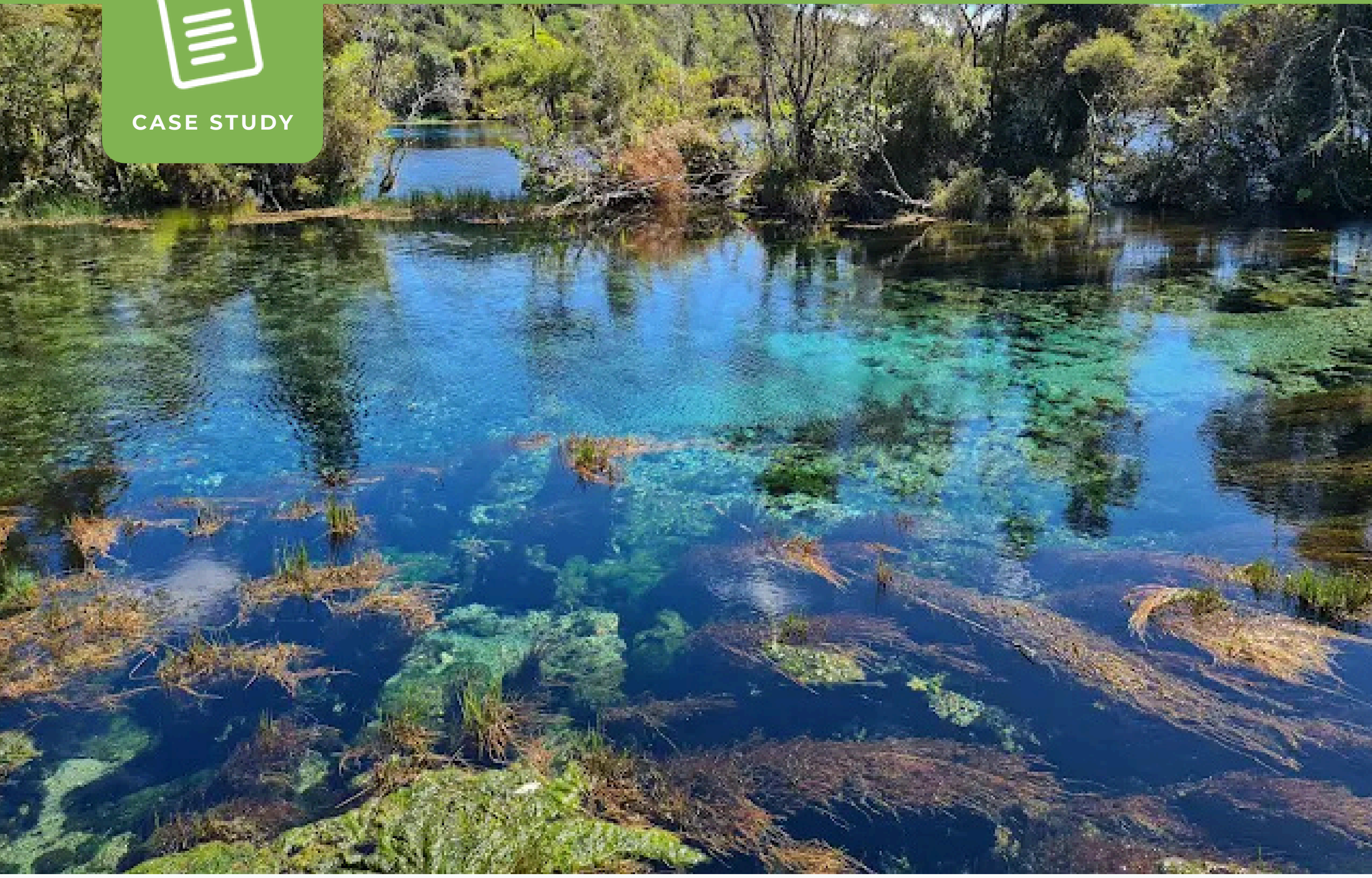

CASE STUDY

Protecting Te Waikoropupū
How Dairy Farming is Adapting on the Marble Aquifer

Objective
This case study provides practical ways that dairy farmers can reduce their nitrogen losses. It focuses on one farmer in the Farmers Across the Marble Aquifer catchment group (FAMA), sharing their experiences and practices.

Introduction
This case study, written by NZ Landcare Trust, follows the Harwood family, who are Golden Bay farmers farming on the Tākaka Marble Aquifer at the top of the South Island. The aquifer feeds Te Waikoropupū Springs - an iconic site renowned for its clarity and cultural significance. A 2023 Water Conservation Order (WCO) requires farmers in this catchment to operate within strict water quality and allocation limits to protect the springs.

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Farming under the recent Water Conservation order for Waiokoropupu Springs

The Waikoropupū Springs are New Zealand's largest cold-water springs, sacred to mana whenua and celebrated for their exceptional clarity, thanks to natural filtration through the Wharepapa Arthur Marble Aquifer. After years of legal deliberation, a WCO was introduced in October 2023 to safeguard these values. It sets limits on water quality and flow, including:

- Nitrate: ≤ 0.41 mg/L by 2038 (10% catchment-wide reduction)
- Clarity: Median ≥ 72 m
- Water allocation: Max 766 L/s (recharge area)
- Minimum spring flow: 6,895 L/s

The council has expanded monitoring to enforce these standards and is developing plan changes that will restrict additional water takes and require reductions in nitrogen losses. Farmers will be asked to reduce their nitrate leaching risk, but the actual amount is still to be set by Tasman District Council.

It is difficult to pinpoint exact contributions in this water body with hugely complex hydrology. Farming will be making a contribution, alongside forestry, point sources, nitrogen-fixing plants such as gorse, natural inputs, and biochemical processes within the aquifer itself such as biofilms, stygofauna and conversion of nitrogen into different forms under low oxygen conditions).There will also be significant lag phases between actions above ground and changes in water quality measured at the spring. An intensive water monitoring programme is being implemented by the council to better understand these complexities. High rainfall (≈1800 mm) and some free-draining soils lead to leaching - around 90 kg N/ha/year on irrigated dairy pasture and 50 kg N/ha/year on non-irrigated land. But there are also an array of soil types in the catchment that have a low leaching risk. High annual rainfall is a major driver of modelled nitrogen leaching in the Tākaka catchment, as increased drainage enhances nitrogen movement through the root zone. However, higher rainfall also contributes to lower average nitrate concentrations through greater dilution compared with drier regions.

The WCO process has been challenging and stressful for farmers. Yet, while court proceedings unfolded, Nigel Harwood and his family, alongside the FAMA, have proactively worked to reduce their farm's impact - driven by their shared commitment to protecting Te Waikoropupū Springs.

Farmers Across the Marble Aquifer (FAMA) Catchment Group

The Harwood farm is a member of FAMA. This group, including mainly dairy farmers, was established in response to the identification of risks to this unique catchment and associated water that highlighted to the farmers the need for a strong precautionary response to land and water use in the Tākaka catchment.

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Dairy farming, and in particular irrigated dairy farming, was identified as likely to be a contributor to the declining nitrate nitrogen water quality trends measured at Te Waikoropupū Springs. FAMA is endeavouring to reduce this uncertainty through collaboration of farming families that are identifying and responding to the risks to water highlighted through WCO process.

Farm History

The Harwood family has farmed in Tākaka since the beginning of the last century. The property was first purchased by great-grandfather Harwood, who bought the Upper Tākaka pub which came with 400 ha of land. Four farming generations later, the farm is 2000 effective ha including a block on the NW Coast about an hour away where some cows are wintered and lambs are finished. There are two brothers running the property; Nigel is CEO and runs the dairy farm, and Jon runs the drystock, sheep, beef, deer dairy support along with their "semi-retired" father who runs the lamb finishing operation. And from the next generation McKenzie has started working on the dairy farm and Cam works on the drystock farm. The farming business employs 10 farm staff members.

Nigel and Dave Harwood at the lamb finishing farm on the North-West Coast

Community Collaboration

The Harwood family has a long history of supporting their local community - dating back to when the family owned the Upper Tākaka pub. Today, their land includes a public walkway at the top of Tākaka Hill and hosts transmission towers for local and national radio, phone, and TV services. The Chorus fibre network also runs through their property.

Nigel has dedicated 15 years to the local high school board and 20 years as Chair of the local Vet Club. Many of the farm's native plantings were established by schoolchildren as part of fundraising projects for the local school .

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Farm Description

The Harwood farm is a highly diversified operation, integrating sheep, deer, dairy, and forestry alongside renewable energy. Key enterprises include:

- Sheep: A flock of 3,100 Romney ewes mated to Romney sires, lambing from 20 September. Around 4,500 lambs (135–140%) are weaned in December and sent to the coastal block for finishing and sale the following October. An additional 2,500 store lambs are purchased annually for finishing.
- Beef: The farm no longer runs beef breeding cows; instead, approximately 400 beef cattle are finished each year, produced mainly from the dairy herd. The drystock unit also winters 700 dairy cows and 100 cows are wintered outside the catchment.
- Deer: 700 red deer hinds and 100 R2 replacements are farmed on 285ha of flats. All progeny are finished on-site and marketed through Silver Fern Farms, targeting the chilled venison market.
- Dairy: The dairy unit runs 885 cows and also generates beef calves for finishing.
- Forestry & Carbon: 150ha of pine forest, including 40ha of post-1990 plantation registered in the ETS. Additionally, 300ha of regenerating native bush are ETS-registered.
- Native Bush & Conservation: The property includes 500ha of native bush - 260ha protected under QEII covenant on Tākaka Hill and 200ha on the northwest coast block. Remaining areas include riparian zones and wetlands which are being expanded.
- Renewable Energy: The farm operates a hydro-electric generation plant.
- Environmental Initiatives: Nigel is a strong advocate for Verspex wasp control.

View from the top of the farm on the Tākaka Hill Road

CASE STUDY

Irrigation and hydro electricity generation

The area receives around 1,800 mm of rainfall annually, most of it falling between March and November. Summers are typically dry, and the soils have a low water-holding capacity of less than 50 mm, making irrigation essential. This combination of high rainfall and irrigation also increases the risk of nitrate leaching.

Most of the flats are irrigated using centre pivots or K-line systems, with water sourced from the Tākaka River and the Waitui Stream. The Tākaka River take is limited and can only occur when flows are released by the Cobb Hydro Station during power generation. The Waitui Stream runs year-round, and water is piped through an on-farm hydroelectric station before being used for irrigation. An allocated amount of water under resource consent can be used over summer.

The hydro system was originally designed to power irrigation but has since been expanded into a $1.6 million plant that now feeds electricity back into the national grid. It generates around $180,000 annually, covering mortgage interest and saving approximately $45,000 in farm power costs. The station produces 420 kW, with 35 kW used for the dairy shed (milk chilling and wash-down) and 125 kW for irrigation during summer. When possible, irrigation is scheduled at night for better water efficiency and to maximize daytime electricity sales when spot prices are higher. However, during hot, dry periods, irrigation must run 24 hours a day to meet pasture evapotranspiration demands. Irrigation rates are managed using 12 soil moisture probes across the dairy farm, which measure soil moisture three times daily.

Current dairy farm system

The main focus of this case study is the dairy platform of 319 ha, with dairy support of 187 ha, as it has the greatest impact on nitrate leaching from the farm. The herd currently numbers 885 Kiwicross cows, a reduction of 35 cows in recent years. Stocking sits at 2.7 cows per hectare, slightly below the national average. Calving begins on 5 August, and cows are typically dried off around 31 May. In 2024/25, 1,244 kg of milk solids per hectare and 4440 kg per cow, which is close to the New Zealand average.

Artificial insemination is used for the first four weeks of mating, with heat detection managed through GEA collars. Follow-up beef bulls are then run with the herd. All progeny are DNA-typed to identify parentage, and dairy replacements are selected primarily on size.

The dairy farm operates as a System 3 unit, with cows fed mainly on irrigated pasture supplemented by 2 kg of barley per cow per day for most of the year. Around 140 tonnes of silage are harvested from the dairy platform, with an additional 150 tonnes cut from the drystock farm and fed out to cows wintered there. Each year, approximately nine hectares of fodder beet are grown, yielding 20–23 tonnes per hectare. This is lifted in April and fed in paddocks at up to 4 kg of dry matter per head per day. Heifers are grazed on the drystock farm from birth until May, after which they move to a summer-safe property for a year. Additional supplements are purchased when required.

CASE STUDY

Bench marked information (DairyNZ)

Parameter	Farm 2016/17 year	Top of the South average	Farm 2024/25	Top of south average
	Start of changing			
Nitrogen kg/ha	200	221	170	162
Cows/ha	2.9	2.9	2.8	2.9
CowMS/cow	422	429	441	438
TDM/ha harvested	9.3	10.4	9.4	10.3
Supplements used	991	682	962	778
Working expenses	$4.00	$3.98	$5.77	$5.63
Operating profit	$409	$632	$5,738	$6,907
Payout	$3.90	$3.90	$10	$10

Benchmarked against 6 dairy farms in the Tasman Region supplied by consultant (final 2024/25 benchmarking figures not released at time of writing). Note the 190 kgN/ha limit came into effect in 1 July 2021

CASE STUDY

Dairy NZ Nitrogen Surplus Comparison (kg N/ha)

System	Baseline (2018)	2025 Year End	Proposed Increased Effluent Area	Change from Baseline	Change from 2025
Whole farm	110	84	84	-26	0
Dairy platform	132	126	109	-23	-17

Notes

DairyNZ nitrogen surplus calculated as (fertiliser N + imported supplement N) − product N.

The whole-farm surplus remains unchanged under the proposed effluent redistribution scenario because total farm nitrogen inputs and outputs remain similar.

Increasing the effluent application area reduces nitrogen intensity on the dairy platform, lowering DairyNZ surplus from 126 to 109 kg N/ha.

This reflects a redistribution of nitrogen across a larger area rather than a change in total nitrogen entering the system.

Dairy Grazing

Replacement heifers are grazed off the dairy platform on support land within the wider farm system. This reduces grazing pressure and nitrogen loading on the milking platform while still maintaining integration within the overall farm system.

CASE STUDY

Strategies to reduce impact of the farm on the environment

Overseer analysis

Overseer is a nutrient management tool used to estimate nutrient use, transfers, and losses within a farm system. It considers factors such as cow numbers, stocking rate, production, and diet to predict nitrogen losses from the cow. Most nitrogen loss occurs through urine patches, where concentrations far exceed what pasture can absorb. Leaching from these patches is then driven by water movement through the soil - a process that varies widely depending on soil type and weather patterns. To account for this, Overseer uses long-term climate data for the farm, and its accuracy improves when detailed soil information is available.

Also predicted by Overseer are phosphate losses to water which are generally low on dairy farms which tend to be on flatter terrain. However, heavy rainfall shortly after fertiliser application, can occasionally wash phosphate into waterways.

Overseer modelling is typically carried out by trained consultants and is a valuable tool for farmers. Its strength lies in allowing farmers to compare different farm system strategies and predict long term average nitrogen leaching across the farm and individual blocks. Nigel has had access to Overseer modelling, and the results are presented in this case study.

Since the monitored base year in 2016/17, the dairy operation has achieved a 13% reduction in modelled nitrogen leaching, as estimated using OverseerFM, decreasing from approximately 63 kg N/ha to 55 kg N/ha across the dairy platform and associated support areas within the aquifer recharge zone. This reduction has been achieved while maintaining similar cow numbers while decreasing stocking rate on a per ha basis, and increasing milk production by 14%, from around 337,000 kg milk solids to 386,000 kg milk solids.

Over the same period, the effective dairy area has increased because of system changes. Irrigated area expanded from approximately 221 ha to 248 ha following the installation of an additional centre pivot and the incorporation of some K-line irrigated land from elsewhere on the wider property. Changes in land use for dairy support have also increased the effective area farmed as part of the dairy system from 410 ha to approximately 506 ha.

At the base period, the dairy platform comprised 297 ha, with 113 ha of dairy support land. By the end of the 2024–25 season, the dairy platform had increased to approximately 319 ha, with dairy support land increasing to around 187 ha.

Overseer modelling indicates that increasing the effluent discharge area (being implemented in 2026) and adjusting fertiliser inputs accordingly could reduce platform-scale modelled nitrogen leaching by a further 11%, making this a relatively straightforward early gain resulting in a potential total of 25% reduction in nitrate leaching.

CASE STUDY

Fertiliser Management
Fertiliser inputs on the farm are guided by regular soil testing and the local fertiliser rep. The Overseer model predicts nutrient inputs from fertiliser, effluent, and supplementary feed, then deducts nutrients leaving the farm in milk, liveweight, and other losses. This helps determine the amount of fertiliser needed to maintain soil fertility or lift nutrient levels into the optimum range for pasture production.

Soil tests are carried out regularly across blocks and, at times, in every paddock. On the dairy platform, Olsen P levels range between 30 and 35, which is considered optimal for pasture growth. Phosphate is applied four times a year to reduce the risk of heavy rainfall washing fertiliser off Pakihi soils which do not retain phosphorus as well as other soil types. Applications are made with a five-metre buffer from waterways.

Using the DairyNZ nitrogen surplus method (fertiliser N + imported feed N – product N), the dairy platform surplus has reduced from 132 kg N/ha in the base period to 126 kg N/ha in 2024/25. With the planned expansion of the effluent area, the platform surplus is expected to reduce further to 109 kg N/ha. These figures are based strictly on the milking platform area; replacement stock are grazed on support land and are not included in the platform calculations.

Changed Effluent Practise
Nigel no longer applies fertiliser to effluent blocks. The main effluent block was carefully chosen for its optimal mix of sand, silt, and clay, which helps minimise leaching losses. Plans are underway in 2026 to increase the area over which effluent is spread, and Nigel intends to reduce nitrate leaching risk on this expanded area by installing an effluent spraying system on the pivot irrigator. Because the pivot is only used during water deficits - confirmed by soil moisture probes - and when long-term forecasts show little rain, most nutrients applied will be taken up by pasture during summer.

CASE STUDY

Balancing diet through changing fodder crop management
New Zealand pastures often contain more protein - and therefore nitrogen - than cows need to meet their dietary requirements. Crude protein levels are highest in spring and autumn and can increase further after nitrogen fertiliser applications, as pasture takes up nitrogen in excess of its growth needs. This surplus nitrogen in the diet contributes to higher nitrogen excretion in urine, which drives nitrate leaching. To help balance the diet and reduce nitrogen losses, Nigel feeds low-protein supplements throughout the year. Cows receive approximately 2 kilograms of barley per day in the shed for most of the season, and in autumn, up to 4 kilograms of fodder beet per cow per day. To maximise the benefits of fodder beet in reducing nitrate leaching - without intensive grazing in paddocks - Nigel lifts the beet and feeds it to cows on pasture. This approach helps lower dietary protein while maintaining energy intake.

Shifting from in-situ grazing of fodder crops to cut-and-carry systems, followed by earlier re-establishment into pasture, has reduced the duration that bare or low-uptake soils are exposed to drainage. This has lowered nitrogen loss risk during autumn and early winter, when leaching vulnerability is highest.

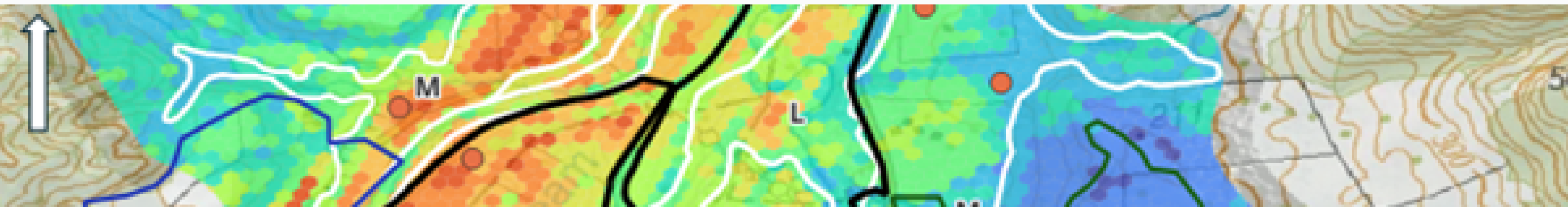
The table below, based on the Australian Feeding Standards, illustrates the impact of balancing the diet on surplus nitrogen excreted in urine.

	Diet					Dry matter intake	Surplus nitrogen in urine	
	MJME	CP%	% diet pasture	% Fodder Beet	% Barley	kgDM/cow/day	g/cow/d	% reduction
Autumn, 1.2 MS/cow/day, 500 kg cow, 0 LWG								
Pasture	10.5	25	100	0	0	14	425	100%
Fodder Beet	12	10	60%	40%	0	13.4	293	70%
Barley	13	11	80%	0%	20%	13.5	358	84%
Spring, 2MS/cow/day, 500 kg cow, 0 LWG								
Pasture	11.8	20	100	0	0	16.9	362	100%
Barley	13	11	80%	0%	20%	16.6	319	88%

Understanding soils to reduce risk

A detailed understanding of soil types across the farm - their proportions of clay, silt, and sand, and the associated environmental risks - has been pivotal in reducing the farm's impact on water quality. It also ensures Overseer modelling is more accurate. Initially, Nigel's initial knowledge of his soils was limited, apart from knowing that much of the farm consisted of Pakihi clay soils, an infamous wet soil common in Golden Bay and the West Coast.

To improve this, Nigel took advantage of funding through Fonterra and his involvement with FAMA to have the farm's soils electronically mapped by Landscape DNA and Land and Water Science. Using a tow-behind device, they produced detailed maps showing soil texture ratios and cation exchange capacity - an indicator of how well soil can hold nutrients. These maps have helped Nigel manage each block for maximum productivity while minimising environmental impact. They also provide graded maps of nitrate leaching risk and overland flow risk, giving Nigel a powerful tool for targeted management.



Nitrate leaching risk for Harwood property. Shading shows nitrate leaching risk from very low (blue) to red (very high). Milking platform are the thick black lines.Polygons are the 2025 S Map soil units, with M, L and VL are the S map nitrate leaching categories. The orange dots are soil pit and auger observations used to ground truth the radiometric map.

CASE STUDY

Reductions in Overseer modelled nitrogen leaching were achieved through improved representation of soil properties in Overseer. Updating soil inputs to reflect high-resolution radiometric soil mapping, rather than default S-map values, resulted in an 8.5% reduction in modelled nitrogen leaching across the farm. This highlights the importance of accurate, site-specific soil data when assessing nitrogen loss risk in complex landscapes.

Pakahi soils dominate much of the Golden Bay region and are well known for their challenges. These clay-rich soils have an impermeable layer about 40 centimetres below the surface, which in their natural state creates waterlogged, swampy conditions. They are low in fertility, have poor phosphate retention, and a low pH. Because of their low ability to hold phosphorus, the best approach is to apply phosphate fertiliser in small, frequent doses. The main environmental risk from Pakahi soils comes from overland flow of clay and nutrients into streams and rivers rather than leaching into the aquifer. Fine clay sediments can remain suspended in water for weeks, reducing water clarity. These soils are also prone to pugging, especially as organic matter builds up, and they require drainage to be farmed effectively. In summer, their low water-holding capacity - around 50 millimetres - means they dry out quickly. However, they pose little risk of nitrate leaching to groundwater and therefore to the springs, which means Nigel can graze these soils during autumn when leaching risk is highest.

Soil mapping revealed far more variation across the farm than Nigel had previously realised. He discovered areas of very free-draining soils dominated by sand and underlain by gravel, which have the highest nitrate leaching risk and therefore pose the greatest threat to the springs. Other soils had a better balance of sand, silt, and clay, offering lower risk. The maps provided clear visual guidance, highlighting red zones of high leaching or runoff risk and enabling Nigel to tailor management strategies for each area.

One practical example is calving. Nigel had always brought cows back to a 25-hectare block for calving because it was dry and easy to strip-graze. However, soil mapping showed this block had the highest leaching potential. He now calves on a smaller area with intermediate soil types that contain more clay but lack the impermeable layer of Pakahi soils. To make this work, he feeds extra supplements during calving to maintain cow condition.

Nigel also learned that Pakahi soils contribute little nitrogen to groundwater and the springs, as their main risk is surface runoff. In fact, these soils grow grass rapidly in spring, which helps absorb nitrogen and reduces the surplus available for leaching.

Refinement of soil inputs in Overseer to reflect site-specific radiometric soil mapping has reduced overestimation of nitrogen losses in some areas and improved confidence in the reported reductions. This has allowed management changes to be evaluated more accurately and targeted more effectively.

CASE STUDY

Open drains.

On Pakahi soils, Nigel has focused on developing shallow, open, grazeable drains to manage excess water. He removed the old tile drainage system after finding it ineffective at reducing pugging and, through trial and error, designed a shallow 1.5-metre open drain system. These drains quickly capture and remove surplus water, helping to minimise pugging during wet periods. At the same time, Nigel maintains grass, ferns, and carex plants within the drains, which trap fine sediment and help filter nutrients. Fencing is placed right to the edge of the drain to prevent bank erosion and ensure water flows freely into the channel.

Open drain in Pakahi soils that cattle graze to the edge, removes water quickly but the drain contains filtering vegetation growth

Leaky weirs and wetlands

Nigel is progressively ensuring that every drain flows into a natural or constructed wetland or includes leaky weirs that create in-drain wetlands. Through trial and error, he has built these weirs using soil and rocks during summer when drains are dry. When water flows, the weirs slow the movement, allowing sediment to settle and forming small wetland areas. Water then flows over and through the weir, maintaining fish passage and forming in-drain wetlands.

Wetlands play a critical role in removing nitrogen, primarily through bacteria that convert nitrate into atmospheric nitrogen, as well as plant uptake that supports this process. These leaky weirs and wetlands also provide nature-based solutions for flood management, reducing peak flows while improving water quality. Nigel has funding for 2026 from the Fonterra/NZ Landcare Trust wetland project to build more leaky weir/in-drain wetlands.

CASE STUDY

Established leaky weir

Planting up leaky weir

CASE STUDY

Constructed wetlands filtering water leaving the farm

CASE STUDY

Other things to consider in the future

Deep rooted species
Farmers in other locations would consider including more deep-rooted pasture species like chicory or lucerne on the free draining soils to improve water use efficiencies and to capture more nitrogen or plantain that reduces nitrate leaching. Unfortunately, in Golden Bay there is a buttercup issue where currently sprays are the only option for control. The alternative pasture species limit the use of buttercup sprays.

Improved understanding of individual cow performance
Consideration should be given to increased use of herd testing and individual animal performance data to better understand variation between cows. This would support more targeted breeding decisions focused on production efficiency, feed conversion, and nitrogen utilisation. Some of this information may already be captured through the recently installed animal collars; however, further analysis could enhance decision-making around culling, replacement selection, and genetic gain.

Wintering outside the aquifer recharge area.
Consideration is being given to wintering a greater proportion of cows outside the Te Waikoropupū Springs recharge area. Modelling suggests this could lead to further reductions in the nitrogen leaching risk, particularly given the heightened vulnerability to losses during winter and early spring.

CASE STUDY

Conclusion

Taken together, the changes described demonstrate that meaningful reductions in nitrogen loss can be achieved through system optimisation rather than production contraction. Improvements in fertiliser and effluent management, diet balance, grazing strategy, and spatial matching of land use to soil risk have reduced nitrogen losses while increasing overall production. In a high-rainfall, highly connected catchment such as the Te Waikoropupū Springs recharge area, these results highlight the importance of integrated, evidence-based farm system design in meeting environmental objectives while maintaining farm viability.

Acknowledgements

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