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PROGRAMME

THE POTENTIAL ROLE OF TRADING SYSTEMS IN THE ALLOCATION OF NUTRIENT DISCHARGE ALLOWANCES

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1. Executive Summary

Trading systems as a tool to reallocate nutrient emissions are currently underutilised in New Zealand. This is primarily due to the under development of the underlying water management policies and regulations required for a trading system to operate effectively.

Water quality must be more proactively managed if we are to reach the goal of having 90% of New Zealand's rivers and lakes swimmable by 2040.

As water management policies are developed the use of trading systems to manage discharge allowances is expected to become more prevalent. But a trading system alone is not a viable solution. A trading system can be used as part of a wider structure for managing water quality. It is also not the only solution available to councils, but it is one that is favoured by economist due to its ability to efficient price and allocate scarce resources.

For a trading system to operate efficiently it must be designed in a way that it is fit-for-purpose and is embraced by potential users. Education plays a huge part in the success of any trading system. This education needs to encompass the underlying purpose or problem which the system is attempting to mitigate, as well as the practicalities of how the system itself operates.

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2. Objective

The objective of this study is to examine when a trading system can be used to allocate nutrient allowances.

The study aimed to test whether a trading system could feasibly be used to manage point or non-point nutrient discharges or a combination of both. That is could one trading system be used to manage both urban and rural pollution via discharges into waterways.

This study investigates the infrastructure required as a precursor to a trading system.

It identifies the role of a trading system and looks at how the trading system can be used as part of a wider solution to manage the discharge of nutrients into waterways.

3. Methodology

Thematic analysis was used to test whether a trading system was a viable option to manage nutrient discharges.

The study involved testing the theory with a selection of industry experts.

An extensive literature review was also undertaken concurrently with the interview process. The literature review was based on the following topics:

Defining the environmental problem that the trading system aimed to solve;

Identifying potential solutions and approaches to the problem and then ascertaining where the trading system fits within the range of solutions;

Investigating where trading systems have been used elsewhere to allocate limited resources;

Identifying the attributes that successful trading systems possess.

4. Introduction

The global dairy industry has a vision to grow in a sustainable manner. This vision is well aligned with the New Zealand's own objectives. But in both instances although the goals are clear what is less clear is how we will achieve them.

"We believe in dairy. We have a strong story to tell in terms of nutrition and also the progress we are making environmentally. No sector is perfect and there is always room for improvement but we have a vision, we have our goals and we will spare no effort in achieving them." Judith Barnes – President of the IDF.

Dr Ren Wang assistant director general of UN's Food and Agricultural Organisation suggests what is now needed is for national frameworks to be developed which set out objectives and performance indicators.

New Zealand already has a national policy framework known as the National Policy Statement on Freshwater Management which is supported by the National Objectives Framework. This framework together with the underlying legislation – the Resource Management Act 1991 – push the responsibility for water quality management to the Regional Council level.

At present councils across New Zealand are grappling to define their environmental goals and develop a plan of how these will be achieved in a manner which best meets the current and future requirements of their region.

Lack of information should not necessarily mean lack of action however. What is needed is an informed judgement that we know enough that we can take actions now that are better than the status quo. We can then seek more information both from fundamental research and by evaluating the effects of our actions and use this information to improve our decisions over time (Kerr, Lauder & Fairman, 2007).

Lack of information should not necessarily mean lack of action

Trading of nutrient discharge allowances is one tool that could be used to reallocate discharge allowances. But before any type of trading system can be considered councils must firstly monitor existing water quality and model the potential impact that existing land uses will have on water quality in the future.

Regional councils – in consultation with the communities they represent – must then decide what level of nutrient discharges their regional water bodies can sustain in order to meet the communities desired level of water quality. Once nutrient levels have been set at a catchment basis then a decision must be made on how the nutrient discharge allowances will be distributed amongst pollutants.

Only then can a trading system for nutrient discharge allowances be used for the purpose of redistributing nutrient discharge allowances. A trading system is a tool which can economically price and reallocate nutrient discharges to the activity which has the greatest return.

5. Literature Review

5.1 Importance of fresh water

Fresh water is essential to New Zealand's economic, environmental, cultural and social well-being. New Zealand currently emanates an image of being clean and green but in order to protect this image, or even justify this image. A responsible approach must be taken to manage our fresh water reserves.

By international standards, New Zealand's water quality is generally good but declining (Parliamentary Commission for the Environment, 2013).

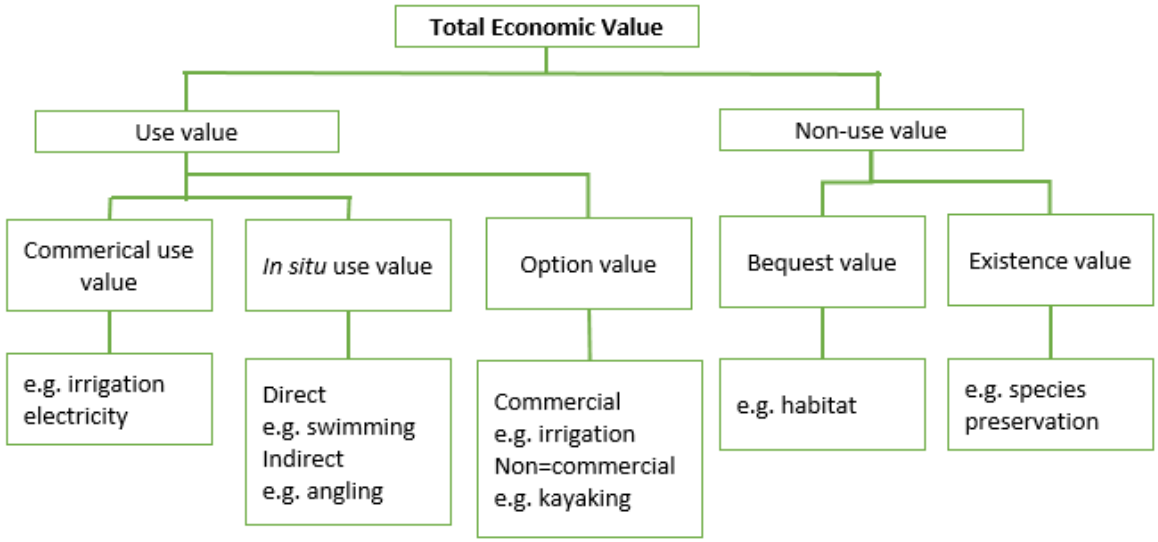
On a per capita basis New Zealand has the second highest volume of renewable fresh water of all countries in the OECD (Gluckman 2017). There is 107,527 m3 or 43 Olympic sized swimming pools worth of water for every person in New Zealand each year.

Irrigation and livestock account for more than 80% of the water use in New Zealand, with just 8% being used as drinking water (Ministry for Environment, 2010).

Despite this abundance of water the Ministry for the Environment has advised, that New Zealand's growing urban populations, together with intensification of agricultural and horticultural land, is putting pressure on water quality.

The value of freshwater is not only the value derived from using water but also the value derived from not using that water. Total Economic Value (TEV) is the sum of all benefits obtainable from a resource (Ministry for the Environment, 2005).

Figure 1: Total Economic Value



Source: Ministry for the Environment

The quality, health, availability and economic value of our fresh waters are under threat. To respond effectively to these challenges and issues, we need to have a good understanding of our freshwater resources, the threats to them and provide a management framework that enables water to contribute both to New Zealand's economic growth and environmental integrity and provides for the values that are important to New Zealanders (Ministry for the Environment, 2017).

New Zealand has 70 major river catchments – 40 in the South Island and 30 in the North Island (Gluckman, 2017).

5.2 Recognition of degradation of fresh water

Water quality is a function of the volume allocated, catchment characteristics, climate and land use (Waikato Regional Council, 2017).

Ecological health in water bodies is partially a function of inputs, such as nutrients from oils and contaminants and from agricultural, urban and industrial activities (Gluckman, 2017).

> *"Water management is now largely land management"*
> ***Waikato Regional Council***

Urban and rural areas both benefit from the availability of fresh water but both environments also contribute to water pollution. Our lakes and rivers are feeling the pressure of more than 150 years of a growing population and changes in the way we use the land (Ministry for the Environment, 2017).

It is now clear that dairy farmers in many regions will need to reduce the amount of nitrogen (N) leached from their farm systems to comply with regional nutrient limits. In some regions, phosphorus (P) losses via sediment erosion or transport in overland flow into streams must also be addressed. (Chapman et al., 2017)

Sources of water pollution are not always obvious. Pollution that comes directly from a factory or a sewage treatment plant is referred to as 'point source' ie the source such as a pipe can be easily identified. In this case it is relatively easy to measure the level of pollution that is being caused by a particular discharge.

Non-point source water pollution, [also referred to as "diffuse" source pollution], arises from a broad group of human activities for which the pollutants have no obvious point of entry into receiving watercourses. Obviously, non-point source pollution is much more difficult to identify, measure and control than point sources. (Ongley, 1996)

Preventing or controlling pollution from non-point sources has been stymied, in part, because little was known about the relative magnitudes of non-point and point sources of nutrients at the national level. Only recently has it been possible to estimate the major sourced of nutrients entering watersheds and relate these inputs and resulting stream loads to land use patterns and regional settings (Puckett, 1995).

The demands from agriculture and urbanisation have led to increasing nutrient concentrations and sedimentation that are adversely affecting water quality (Blake-Kaye et al. 2014).

Nitrogen leaching from agricultural soils is estimated to have increased 29 percent from 1990 to 2012 (Ministry for the Environment, 2017).

All of NZ's regional and unitary councils, are involved in monitoring water quality in rivers (over 1000 reaches), lakes (around 100) and groundwater (around 1000 bores).

There is no simple way to measure water quality. Multiple measurement variables are used in virtually all assessments of water quality (Gluckman 2017).

Measures used differ depending on whether you are measuring the health of a river, lake or wetland. There is a vast number of differing measures including factors such as temperature, acidity (pH), nitrate-nitrogen NO_3-N), ammoniacal-nitrogen (NH_4-N), total nitrogen (TN), dissolved reactive phosphorus (DRP), total phosphorus (TP), E-coli, water clarity etc. Various indices have been developed to combine a range of measures. Such indices include: macroinvertebrate community index (MCI) which is a measure of the number of bottom dwelling invertebrates; Wetland Condition Index (WCI) which includes five ecological indicators; topical level index (TLI), etc.

Water quality and ecosystem health (as indicated by measurements of nutrients, E. coli and macroinvertebrate scores) generally worsen across land-cover classes in the following order: natural, exotic forest, pastoral, urban (Gluckman 2017).

In urban environments, contaminants enter water bodies mainly through stormwater and wastewater networks, illegal connections to the networks, and leaky pipes, pumps, and connections. In agricultural areas, nutrients and

pathogens (organisms that can cause disease) come from animal waste and urine, and fertilisers (Ministry for the Environment and Stats NZ).

In rural areas, we are starting to recognise that we are storing up problems for the future. The evidence is now starting to show the effects of land use practices 50 plus years ago and we know that this is just the beginning as pastoral farming has intensified since that time (Waikato Regional Council).

New Zealand is one of the most urbanised countries in the OECD with 86% of the population living in cities and towns (OECD 2017). The high proportion of the population living in cities may come as a surprise given New Zealand is more widely known for its vast open spaces. The relatively large urban population may be contributing to the perception that agriculture (particularly dairying) is solely responsible for the degradation of fresh water.

People often view pollution as being done by "others" (firms) and victims as "us" (Braaten, Brekke and Rogeberg, 2015).

Data collated by dairy companies indicates that more than 80% of dairy farms now have nutrient budgets. But only 40% of the public agree that dairy farmers are good stewards of the environment (DairyNZ 2017). The dairy industry has a target to improve the public perception that 'dairy farmers are good stewards of the environment' to 80% by 2020.

Only 40% of the public agree that dairy farmers are good stewards of the environment
DairyNZ

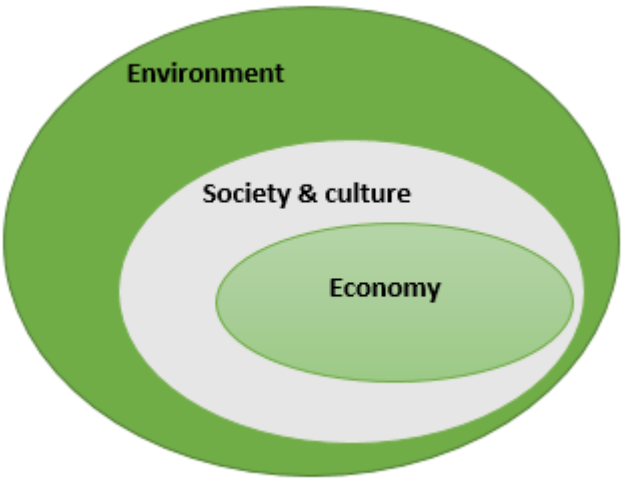
It is not realistic to return all our fresh water to a pristine state. But nor can we afford not to act. The quality of our fresh water is one of the biggest environmental challenges that we face in this clean green country of ours (Parliamentary Commissioner for the Environment, 2012).

5.21 Economic & social consequences of environmental change

It is generally accepted that there is a trade-off between practices that are positive for the economy and practices that are good for the environment.

Water needs to be managed and used to provide for the economic, environmental, social and cultural well-being of New Zealanders. When it comes to water, these well-beings do not stand apart. Environmental wellbeing is necessary to support cultural values and economic production. Social wellbeing contributes to a well-functioning economy. Economic activity gives people the means to enjoy the environment and the social and cultural values it supports. (Kaye-Blake et al. 2014)

Figure 2: Embedded systems - environment, society, economy



Source: NZIER

How Section 5 (2) of the Resource Management Act (1991) is interpreted determines the extent to which environmental outcomes need to be balanced against economic wellbeing.

Resource Management Act, Section 5 - Purpose

(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.

(2) In this Act, **sustainable management** means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while—

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Much of this debate has centred on the interpretation of the conjunction 'while' in section 5(2). One school of thought was that section 5(2) requires the antecedent matters [which includes economic wellbeing] to be balanced against the three subparagraphs. The other school of thought was that the matters in (a) to (c) amount to non-negotiable bottom lines which must be met in all cases (Environment Guide, 2015).

It is apparent that the original intention of the values set out in paragraphs (a) to (c) in section 5(2) set out a set of 'biophysical bottom lines' (Dawson 2013) however the actual approach to the interpretation of 'sustainable management' by the Courts has been significantly different.

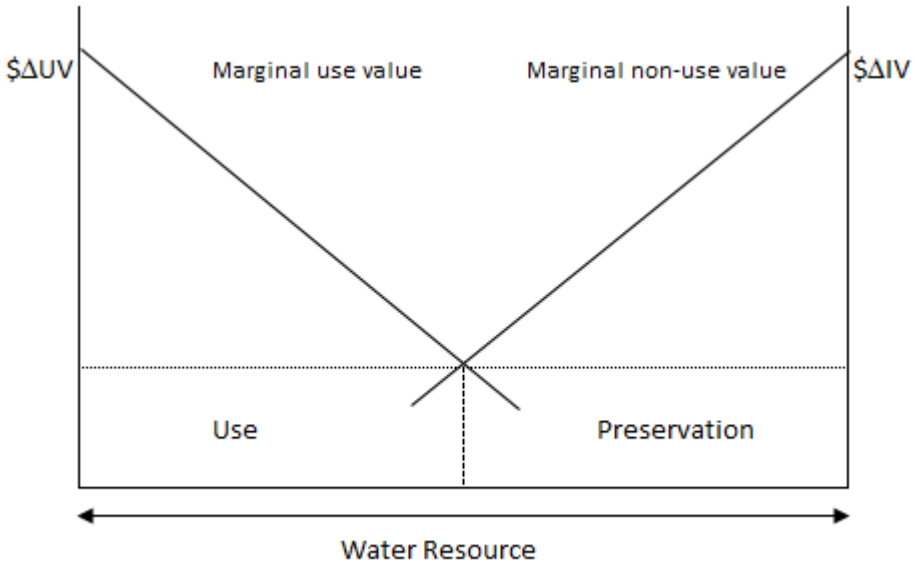
The current degradation of regional fresh water has been assisted by a 20th century understanding that there is a balance to be had between social, economic and environmental aspirations. Unfortunately the current situation is that in some areas, economic use of fresh water has degraded them to an unacceptable level (Waikato Regional Council, 2017).

On one hand [agriculture] is at the core of our economy, on the other it has led to rapid changes in land use, particularly through dairy expansion, with concomitant major and adverse impacts on the quality of our fresh water estate (Gluckman, 2017).

In potential conflict with the freshwater management policy, the government wants one million ha of land under irrigation by 2025. It also seeks to double primary industry exports in real terms between 2012 and 2025. To that end, it has established grants and concessionary financing for irrigation projects. However, this financial support lacks systematic consideration of environmental and community costs (OCED 2017).

There needs to be a balance between the use and preservation of water. If a value can be placed on both the use and the preservation of water then the best overall economic outcome can be modelled (see Figure 3).

Figure 3: Balance water use values with non-use values



Source: Ministry for the Environment

The dairy industry has taken ownership of environmental issues by the adoption of voluntary environmental schemes (Coghlan, 2015). However to date the industry has largely resisted tighter rules on nutrient emissions.

The Sustainable Dairying: Water Accord is a set of national good management practice benchmarks aimed at lifting environmental performance on dairy farms. It was developed under the oversight of the Dairy Environmental Leadership Group which consists of farmers, dairy companies, central government, regional government, and the Federation of Maori Authorities. This is an industry driven initiative aimed at encouraging farmers to do best practice by setting goals and measuring the performance against these.

In terms of nutrient management the expectation is that dairy farmers will manage N and P loss from dairy farming systems, acknowledge the need to manage within nutrient loss limits, and pursue continuous improvements in nutrient use efficiency (DairyNZ, 2016).

We support initiatives that incentivise farmers to use the best environmental practices" (Mackle, 2017). There is also a general expectation that meeting environmental standards will become increasingly challenging in the future. "I see the decade ahead of us to be transformational for our sector. Never before have we had a stronger mandate for the dairy sector to concentrate on productivity – to produce more from less, and to do so sustainably," (Harris, 2017).

Some aspects the dairy industry is hanging its hat on are:

- 97% of waterways on dairy farms are now fenced to exclude cattle from entering water ways.
- Industry knowledge is improving with 162 rural professionals now Certified Nutrient Management Advisors
- Compliance levels for dairy effluent systems are improving (DairyNZ, 2017)

The Land and Water Forum is a group which represents 55 organisations and has 13 central and local government active partners[1]. In its Fourth Report the Forum recommends approaches which will encourage and reward all the participants - on whose action change after all depends - to use water more efficiently and more productively, to allow them to innovate and invest with confidence, and to give access to new users and new uses of water.

The report suggests that by allowing flexibility, improvements in the efficiency of water use and the management of discharges will be driven primarily by the decisions of individual businesses and water users. They will need to decide

[1] Based on data published on the Land and Water Forum website, accessed November 3, 2017.

how best to use their resources (including the limits on water use and discharges) to enhance productivity, increase production, and manage their land and water use in the most efficient way. That is why it is important to give them the flexibility necessary to innovate and manage as effectively as they can within limits. The recommendations in the Forum's reports allow flexibility through:

- providing individual allocations of water and moving toward individual discharge allocations where feasible – allowing individual businesses and water users the flexibility to innovate and manage within their allocation as they see fit;
- freeing up the transfer of consents to take water, and (in future) discharge contaminants, to allow businesses to increase or reduce their water use and discharges and allow resources to move more easily to their highest valued use over time;
- allowing land use to change over time in response to changes in all of the inputs that land and water users have to consider – markets, economic trends, climate, soil quality, as well as water availability and environmental limits;
- the systemisation and continuous improvement of sector good management practices (GMPs) and their flexible application based on conditions at the property-level (Land and Water Forum, 2015).

5.22 How significant is the water quality issue?

Water quality is deteriorating in many rivers and lakes in New Zealand. There is also a clear link between the intensification of agriculture and poorer water quality. What is less clearly defined is which catchments are already overloaded or nearing capacity.

Coghlan, 2015 states that urine and effluent from dairy cows is a major source of water pollution. Concentrations of nutrients and E. coli increased, and macroinvertebrate community index (MCI) scores and visual clarity decreased, with increasing proportions of high-intensity agricultural and urban land cover in the upstream catchment. (Larned, Snelder, and Unwin, 2016).

Nitrogen and phosphate are the two nutrients primarily associated with the degradation of water quality. How these nutrients enter water systems differs. Therefore potential solutions for limiting the discharge on one of these nutrients will not necessarily reduce the risk of the other entering the water system.

The complications of maintaining acceptable levels of nitrogen and phosphorus are multiple and often interacting and cumulative – small amounts leaching from multiple properties add up to significant issues when they accumulate in downstream waterbodies (Gluckman 2017).

Nitrogen (N)

Nitrogen is the nutrient that attracts the most attention. Once nitrogen reaches water it is readily dispersed and can result in deterioration of groundwater quality (Close et al., 2008).

Nitrogen is a highly mobile element. It has been described as having 'slippery chemistry' because it exists in many forms, and can change between these forms rapidly in response to environmental conditions (Chapman et al., 2017).

The form of nitrogen leached below the root zone is nitrate. Nitrate is not retained on soil particles, so moves with water in drainage. In contrast, ammonia is weakly bound to the soil and doesn't move as readily. Nitrogen is also lost to the air as nitrous oxide (N^20) and dinitrogen gas (N^2). Nitrogen hits the soil as urea (in cow urine or fertiliser), where it is transformed to ammonia, then to nitrate, and finally to N^2O and N^2. Transformation beyond ammonia means increased risk of nitrogen losses. Nitrogen not taken up by plants as ammonia or nitrate or immobilised into soil organic matter is destined to be lost from the system (Chapman et al., 2017).

Nitrogen occurs in forms that are highly soluble in water and so can travel via groundwater as well as across surfaces. This makes it particularly elusive – preventing it getting into water is a major challenge (Parliamentary Commissioner for the Environment, 2012).

Data collated by Stats NZ and the Ministry for the Environment show nitrate-nitrogen concentrations 18 times higher in the urban land-cover class, and ten times higher in the pastoral class compared with the native class for the period 2009–13. Of 175 monitored river sites in the pastoral class, nitrate-nitrogen trends were worsening at 61 percent and improving at 22 percent of sites for the period 1994–2013 (Ministry for the Environment and Statistics NZ, 2017).

Nitrogen surplus has increased in step with the growth in dairy herds (OECD 2017).

The biggest source of nitrogen in New Zealand's waterways is urine from farm animals. Urine contains urea which is rich in nitrogen. Urine thus acts as a nitrogen fertiliser, but urine patches in paddocks can be too much of a good thing – the grass cannot grow fast enough to take up all the nitrogen, particularly in winter. The soluble excess nitrogen seeps down into groundwater or washes off the paddock into streams. Wasted nitrogen fertiliser is a much smaller source of nitrogen in fresh water than urine (Parliamentary Commissioner for the Environment 2012).

The more nitrogen you use, the more you loss
DairyNZ

The risk of nitrogen runoff from applying too much fertiliser is greatest in intensive horticulture and when growing winter forage crops. (Menneer et al., 2004; Clothier et al., 2007; Monaghan et al., 2007).

Nutrient losses from farmland is measured by the amount lost in kilograms per hectare per year. Low intensity agricultural properties typically lose around 10 kg or less of nitrogen per hectare per year while high-intensity properties (e.g., some types of horticulture or an irrigated dairy farm on free-draining soils) can be lose more than 80 kg of nitrogen per hectare per year (Gluckman 2017).

The national average N-loss, based on 2015/16 data in Table 1, was 39 kg N/ha/yr (DairyNZ, 2016).

Figure 4: Average nitrogen loss across 13 regions

	Average N-loss (kg N/ha/yr)	Sample size (number of farms)
Northland	23	687
Auckland	20	237
Waikato	34	3446
Bay of Plenty	42	571
Gisborne/Hawkes Bay	36	86
Taranaki	51	1329
Manawatu	28	696
Wellington	33	154
Tasman	69	125
Nelson/Marlborough	42	51
Canterbury	64	1073
Otago	39	362
Southland	32	699
Average	**39**	

Sources: DairyNZ, Dairy company data based on the 2015-16 season

Nitrogen can be measured as a total or in its dissolved form:

Dissolved inorganic nitrogen (DIN) includes nitrate, ammonia, and other forms of inorganic nitrogen. It is nitrogen available for plant growth.

Total nitrogen (TN) is the total amount of nitrogen present in water. It includes nitrogen from dead plants and animals as well as DIN. When dead plants and animals decay, they release nitrogen into the water, so it becomes available for plant growth.

Phosphate (P)

Under natural conditions phosphorus is typically scarce in water. In the late 1960s scientists discovered phosphorus contributed by human activity to be a major cause of excessive algae growth and degraded lake water quality. (Minnesota Pollution Control Agency, 2008)

As phosphate loading continues and there is a build-up of phosphate in the lake or surface water ecosystem, the aging process of lake or surface water ecosystem will be accelerated (Oram, 2014).

Phosphorus gets into water with soil and if the soil can be stopped from getting into water, so will the phosphorus (Parliamentary Commissioner for the Environment, 2012).

Therefore solutions to mitigate sediment runoff into waterways should also reduce phosphate levels.

Stock exclusion from waterways, ensuring crossings are bridged/culverted, effective riparian management, and good practice effluent management are all important in mitigating phosphorus loss risks on farm. Other farm practices that can influence P loss risk include management of tracks and races and wintering practices including cropping (DairyNZ, 2016).

Excluding stock from water ways is focussed on cattle. This is because cattle tend to cause greater damage to the banks of rivers, like lingering in rivers, and defecate more often when standing in water, while sheep tend to visit streams to drink but don't loiter in them. A study undertaken in the UK during the summer of 2010 recorded that cattle spent approximately 2% of their time in the aquatic environment and approximately 7% of their time in the riparian zone. Cattle also defecated five times more frequently in-stream than the average defecation frequency (Bond, Sear, and Edwards, 2012).

Phosphorus can be measured as a total or in its dissolved form:

Dissolved reactive phosphorus (DRP) is the amount of phosphorus that has dissolved in water and is therefore readily available for plant growth.

Total phosphorus (TP) is the total amount of phosphorus present in water. It includes the phosphate that is stuck to sediment as well as DRP. TP is a particularly important measure for lakes, because over time phosphate that is stuck to sediment can be released and become available for plant growth.

Sediment

While sediment movement is a natural part of a functioning freshwater ecosystem, human activities around a waterway (such as dam or road construction or land use change from native forest to pasture) can greatly increase the amount of sediment that enters the system (NIWA)

Milliman and Syvitski (1992) estimate global sediment load to oceans in the mid-20th century at 20 thousand million tonne per year. They believe that almost 50% of the global total comes from erosion associated with high relief on islands of Oceania.

There are various methods used for measuring both sediment that is suspended in water and sediment that has settled on river and lake beds. Suspended sediment can be measured directly (in grams of sediment per litre of water), or inferred by measuring the murkiness of the water or its opposite, the clarity of the water. (Parliamentary Commissioner for the Environment, 2012)

Measurement of phosphorus transport in North America and Europe indicate that as much as 90% of the total phosphorus flux in rivers can be in association with suspended sediment (Ongley, 1996).

Most soil conservation and sediment control measures are only effective in combating a specific soil erosion or sediment control measures are only effective in combating a specific soil erosion or sediment delivery process. Therefore, the general implementation of one single conservation measure to a whole catchment will not be as effective as its application in those locations where it is most suited. (Verstraeten et al. 2002).

NIWA recommends the following actions as ways to minimise the effects of sediment on water quality.

- Fence waterways to prevent stock access to stream banks.
- Create and maintain a vegetated riparian buffer.
- Create a buffer zone of long grass from 5 to 10 m width to filter overland flow of sediments to waterways.
- During earthworks activities incorporate devices such as riparian buffers, mesh fences, sediment retention ponds, sediment traps, or hay bales in drainage runoff zones to reduce sediment pollution.
- Avoid discharging runoff directly into waterways. Install sediment traps, especially on each side of stream crossings or bridges.

The use of minimum or no tillage cultivation practices is also recommended by DairyNZ to reduce soil erosion and sediment entering water ways (DairyNZ, 2016). DairyNZ has developed regional guides detailing best practices to reduce sediment runoff and phosphate losses specific to each region.

Pathogens (eg. E.Coli)

The main sources of pathogens in fresh water are human sewage and animal manure (Parliamentary Commissioner for the Environment, 2012).

A water sample from the nearest river will almost certainly contain the Campylobacter bacteria, which can cause diarrhoea and vomiting (Till et al., 2008).

There are two commonly used ways of measuring pathogens in fresh water. Both are measured in units of the number of live bacteria per 100 millilitres of water.

1. Faecal coliform (FC) bacteria counts measure sewage and manure contamination in water. This measure can give a false impression of health risk because coliforms of plant (not faecal) origin can grow when water samples are tested.
2. Escherichia coli (E. coli) bacteria live in the guts of mammals and birds, so any sewage or manure contains many millions of these bacteria. Most E. coli strains are not harmful. However, high levels of E. coli indicate the presence of faecal material in the water, and therefore other pathogens too. So the level of E. coli in a water sample indicates how likely the water is to cause disease. Water is only deemed safe for drinking if there are no E. coli present. When E. coli counts in rivers and lakes are detected above 550 per 100 millilitres, health authorities put up signs stating 'Swimming or collecting shellfish is not recommended' (Parliamentary Commissioner for the Environment, 2012).

Reducing E.coli levels is critical to achieve the government goal of making 90% of New Zealand's lakes and rivers swimmable by 2040 (Ministry for Environment, 2017).

Reducing E.coli levels is critical to achieve the government goal of making 90% of New Zealand's lakes and rivers swimmable by 2040

The microbial test used to assess possible pathogen presence in New Zealand freshwater systems is detection of Escherichia coli (E.coli), which serves as a cost-effective indicator of contamination from animal or human faecal sources. Quantitative risk assessments have been used to determine levels of E. coli that correspond to a given risk level for infection by pathogens such as Campylobacter, Cryptosporidium, Giardia, Salmonellae and hepatitis A that are likely to be present if the water is contaminated with faecal matter (Gluckman 2017).

E. coli concentrations can be elevated during summer if animals have unrestricted access to streams (i.e., no fencing), because increased heat stress attracts animals to water, and reduced streamflow provides less dilution of faecal inputs (Donnison et al., 2004; Bagshaw, 2008).

Data collated by the Ministry for Environment covering the 2009 to 2013 period indicates E.coli concentration was 22 times higher in the urban land-cover class and 9.5 times higher in the pastoral class compared with the native class.

5.3 Roles of regulatory authorities

New Zealand has had little consistent water policy over time. The ad-hoc responses of the 1840 – 1930s were replaced with an interventionist approach for the period from 1941 – 1989. Since then, the Resource Management Act (1991) has given regional councils the responsibility of managing the complex trade-offs associated with water management (Kaye-Blake et al., 2014).

The timeline below details some the important legislation and policies relating to environmental management.

1953 – Waters Pollution Act 1953 introduced, creating the Pollution Advisory Council to regulate end-of-pipe discharges into water. 1967 – Water and Soil Conservation Act 1967 sets in place a single consenting system to regulate water use, including discharges.

1991 – Resource Management Act 1991 introduced, creating an integrated consenting system for land, water, and air, guided by the principle of 'sustainable management'. Point sources of water pollution become increasingly tightly controlled, sparking investment in upgrading wastewater treatment.

2008 – Land and Water Forum established as a cross-sector collaborative with the objective of developing a common direction for freshwater management in New Zealand and providing advice to government.

2011 – National Policy Statement on Freshwater Management 2011 introduced, with the primary objective of improving freshwater management by regional councils.

2014 – National Policy Statement (NPS) on Freshwater Management 2014 amended, and national bottom lines for water quality established through the National Objectives Framework. Regional councils have until 2025 to implement the NPS. Part of this directs regional councils to establish objectives and set limits for fresh water in their regional plans.

2015 – Environment Reporting Act 2015 requires the Ministry for the Environment and Stats NZ to report on the state of our environment, the pressures that affect the state, and how this state influences aspects of the environment and our well-being. Report titled 'Our fresh water 2017' was released in April 2017.

2017- National Policy Statement (NPS) on Freshwater Management 2014 was amended, effective September 6, 2017, and now includes an additional objective (amongst others) to 'support the government objective of making 90% of New Zealand's rivers and lakes swimmable by 2040 by requiring regional councils to improve water quality and report every five years on what they are doing to achieve regional targets'.

5.31 Central government role and position

The Ministry for the Environment is the government's principal adviser on the environment but is not involved in day-to-day environmental management.

The Ministry for the Environment provides:

- environmental management systems, including laws, regulations and national environmental standards
- national direction through national policy statements and strategies
- guidance and training on best practice
- information about the health of the environment.

Central government's role is to set the scene, direct the approach, allocate roles, and help to ensure that the means (which include critically important science and data) are available (Bisley, 2016).

Exactly how the Labour, NZ First, Greens coalition government will roll out new environmental policies is not yet clear. The new Prime Minister Jacinda Ardern has acknowledged there is 'work to do on the RMA' (Smellie, 2017).

The Resource Management Act (RMA) process essentially allocates water on a first-in, first-served basis (New Zealand Business Council for Sustainable Development, 2008).

When water is already fully allocated, new applications are rejected, even if they offer better economic and environmental outcomes than those already granted (Kaye-Blake et al. 2014).

New Zealand's primary environmental legislation, the Resource Management Act 1991 (RMA), is enabling in principle, but makes market establishment challenging in practice. A key problem is the ambiguity of 'sustainable management', which provides a poor basis for defining environmental goals (Greenhaugh et al., 2010).

5.32 Role of Regional Governments

Under the Resource Management Act 1991 Regional Councils are charged with managing the natural and physical resources of a region. Part of the responsibilities of Regional Councils is the allocation of water and contaminant discharge capacity.

Councils are required to implement the Freshwater NPS in their policies and plans as promptly as is reasonable in the circumstances, and so it is fully completed by no later than 31 December 2025 (Although if council require more planning time they can extend implementation out to 2030). So far just two regional councils – Otago Regional Council and West Coast Regional Council have implemented their plan. The other councils expect to complete implementing programme sometime between 2020 and 2028 (See Appendix 1 for more details).

Many regional councils are struggling with the enormity of the task they have at hand to develop policies, and do so in a collaborative manner that allows their members to have a say in how any policies and rules will be developed and implemented.

The Waikato Regional Council acknowledges that in order to implement the requirements of the National Policy Statement on Freshwater will require a shift from reactively implementing central government's resource management legislation to one of shaping the agenda by working with regional communities, partners and stakeholders to access new tools and use all policy options. It recognises an imperative for change and that to change direction, we need to do things differently (Waikato Regional Council, 2017).

The challenge for many councils is that they don't have a clear understanding of where they currently are in relation to the nutrient capacity of their freshwater systems. There is an urgent need to gain such understandings in order to prevent over capitalisation and the creation of stranded economic assets at both the property and processing level.

> *The challenge for the Waikato Regional Council is that we don't have a clear understanding of how close we are to, or how far we have exceeded the carrying capacity of the region's fresh water.*
> ***Waikato Regional Council***

5.4 Water management approaches

There are various ways to encourage change in behaviours. These are positive incentives, regulations and information, colloquially known as carrots, sticks and sermons (Waikato Regional Council).

5.41 Positive incentives

Positive incentives can be used to improve environmental standards. Private companies sometimes take this approach by paying a higher price or a bonus to their supplier who meet certain criteria.

An example of this is Synlait's Lead with Pride™ farm assurance program which requires certain criteria to be met in four areas: environment, animal health & welfare, milk quality, social responsibility. To become Certified Members, suppliers must achieve excellence in efficient water and irrigation management, effective effluent management, improved biodiversity, soil quality, emissions and energy management.

Miraka also incentivises its milk suppliers through Te Ara Miraka (The Miraka Way) farming excellence programme. This programme has five aspects it covers including Nga Tangata (people), Te Taiao (environment), Nga Kau (cows), Miraka (milk), and Taurikura (prosperity). The Te Taiao section focuses on sediment, nutrient runoff, E.Coli, and toxin leaching.

5.42 Policy / Rule based approaches

Rules are useful for setting standards or bottom lines so that policies can be enforced.

Regulatory tools are needed to ensure takes and discharges are within the capacity of the freshwater resource, but they are very blunt instruments when attempting to influence behavioural changes and the actions of individuals on private land (Waikato Regional Council, 2017).

A study undertaken by a Swedish university (Braaten et al. 2015) indicated that command and control [methods] were preferred to economic instruments like quotas and taxes, and while some schemes involving tradable emission quotas have been implemented, legal instruments still dominate.

Command-and-control is comforting to politicians and people: governments know what they are asking for, people know what they are getting, companies know what they are supposed to deliver; the only people who do not like it are economists (Economist, 1989).

It is a common belief that the primary advantage of using command-and-control mechanisms is that they provide a clear outcome, while being comparatively simple to monitor compliance. Therefore, it is possible that an emissions reduction goal can be reached; if not, the violators will pay a fine.

The United States Environmental Literacy Council however, advises that command-and-control mechanisms have several drawbacks. It is very costly for regulators to gather necessary information, and they often have to collect it from the sources that they are regulating – creating the possibility for inaccurate or dishonest reporting. Polluters also have very little choice about how to meet the standards; therefore, there is no incentive to research new and creative ways to reduce their emissions.

In the New Zealand context dishonest reporting is may be less of an issue given any nutrient management is typically carried out by certified consultants. There may however be instances where for example there may be an incentive to incorrectly report stock numbers or fertiliser use in order to be exempt from having to provide a more in-depth nutrient management plan.

5.43 Knowledge transfer – promoting best practice

Much of the industry led initiatives in the area of improving environmental practises have been based on knowledge sharing of currently known best practice and undertaking further scientific research.

DairyNZ includes environmental stewardship as part of its strategy for sustainable dairy farming 2013-2020. Within its strategy framework it has the following two environmental targets:

- The dairy industry fulfils all commitments listed in the Sustainable Dairying Water Accord (by 2017 it had achieved 6 out of 10 targets).
- 80% of New Zealanders agree dairy farmers are good stewards of the environment by 2020. (this moved from 37% in 2013 to 41% in 2017 – so still well off target).

DairyNZ shares learnings gained from on-farm research via field-days, and reports and information that are published on its website or distributed directly to farmers.

In partnership with regional councils, DairyNZ has produced riparian planting guides for 13 regions. A lot of promotion of best practise to date has focused on riparian management. Wintering management is another focus area due to the potential for large nutrient losses occurring at this time of the year.

Pastoral 21 (P21) is a collaborative research venture involving DairyNZ, Fonterra, the Dairy Companies Association of New Zealand (DCANZ), Beef + Lamb New Zealand, and the Ministry of Business, Innovation and Employment. The programme is designed to boost farm productivity and reduced environmental impacts by providing proven, profitable, simple, adoption-ready systems that lift production and reduce nutrient loss.

Its twin goals are:

- a $110/ha/year increase in average profitability from dairy production, with a 30% reduction in nitrogen and phosphorus losses to water
- a 3% annual meat productivity increase, while containing or reducing environmental footprint.

DairyNZ principal scientist David Chapman says the P21 studies demonstrated that, compared with benchmark regional farms, nitrate leaching reductions of 30-40% are possible through a combination of system-level changes. Reducing total nitrogen (N) inputs in fertiliser and supplements, plus capturing autumn urinary N on a standoff pad, all combine to lower nitrate leaching. But profit per hectare was similar to, or slightly less, than the benchmark system. (DairyNZ, 2017)

Ongoing research has confirmed the potential of several new approaches to reducing nitrate leaching. Plantain and fodder beet are emerging as the best feed options to reduce nitrogen (N) loss, while catch crops following winter crops take up residual N in the soil. Salt supplementation of cows in autumn has now been proved to reduce N leaching. The potential to select cows with lower urinary N output has been raised and research planning is underway to test this hypothesis. (DairyNZ, 2017)

Due to the research carried out as part of P21 and other research DairyNZ scientists are confident that there are viable system options that can reduce N and P losses by 30-40%.

But is simply promoting best practices is unlikely to be sufficient to improve water quality to the standards sought. In areas where water quality is currently high best practise may be sufficient, but in areas where nutrient discharge levels are already too high or approaching this level than relying on farmers to implement best practises won't make a big enough difference.

5.44 Input versus output approaches

It is generally agreed that limits should be placed on outputs – such as N and P – rather than inputs such as the amount of fertiliser used or the number of cows farmed. The output approach is preferable as this will encourage innovation on-farm.

The OECD goes a step further recommending New Zealand decouple growth from natural resource use (OECD, 2017).

5.45 Allocating fresh water

The Ministry for the Environment (MfE) has been working alongside the Land and Water Forum, the Iwi Leaders Group, and other partners to develop clearer direction for councils. MfE aims to support regional councils to maximise the economic opportunity from their fresh water, while working within environmental limits.

A Technical Advisory Group was established in 2016. In November 2016, a review of allocation in different jurisdictions was produced. The Group is due to report back in late 2017, for Government, the Land and Water Forum and Freshwater Iwi Leaders Group consideration in 2018.

The Ministry for the Environment proposes that better allocation of fresh water will ensure our freshwater resources are used as efficiently and equitably as is possible and will be protected and, if needed, enhanced.

Under the RMA, water is allocated on a first-in, first-served basis. In catchments where restoration of water bodies has required substantial decreases in discharges, regional councils have begun developing new approaches for allocating discharge allowances. There is limited transfer of takes or discharges between users.

First-in first-served is administratively simple and is an appropriate mechanism when a resource is not under pressure and not approaching sustainability limits. However, once demand for these resources starts approaching limits, the system lacks sufficient incentives for water and discharges to shift to higher value uses (Smith & Guy, 2016).

5.46 Economic allocation tools

Ultimately, any strategy to reduce agricultural impacts on water quality will only be successful if it is implemented at the farm level. Therefore, implementation of control measures at the farm level will only be successful and sustainable if the farmer can determine that it is in his economic interest to undertake such measures (Ongley, 1996).

The best way for capitalism to do its job is for its proponents to insist on clear rules, fairly enforced. To insist that organisations not only enjoy the benefits of what they create, but bear the costs as well (Godin, 2017).

Economic tools to address water allocation and pollution are under-used according to the OECD. This is partly because the government declared that “no one owns water”. Charges for water abstraction and pollution discharges are minimal, covering only the administrative costs of resource consents (OECD, 2017).

In 2015 the Land and Water Forum recommended that councils implement a system of individual discharge allocations. These would be transferable if permitted by conditions in the catchment. Such a system is likely to be the most economically efficient as it allows dischargers flexibility in how they manage within their allocation and allows discharge allocations to move to their highest-value uses over time (Land and Water Forum). In the near term, such an approach is feasible for nitrogen, and possibly also phosphorus, but a number of precursor steps must first be undertaken.

Ultimately, any strategy to reduce agricultural impacts on water quality will only be successful if it is implemented at the farm level. Therefore, implementation of control measures at the farm level will only be successful and sustainable if the farmer can determine that it is in his economic interest to undertake such measures (Ongley, 1996).

Enabling transfer of allocated takes and discharges is important for minimising the costs of reducing over-allocation, as transfer will help to ensure that within the reduced overall cap, takes and discharges move to the best economic uses (Land and Water Forum, 2015).

The Forum also suggests that Central government should also ensure that its funding schemes enable it to contribute financially to efforts to bring highly over-allocated catchments back within limits.

A cap-and-trade scheme is a market-based policy approach. The ‘cap’ is an effective means of limiting the quantity of an input or output. The level of the cap determines the scarcity of the right, and provides the impetus to trade. The ability to ‘trade’ the right to emit provides efficiency gains; emitters whose marginal costs of reducing emissions are lower than the market price of the right can sell their rights to those with higher marginal costs of reduction (Barns and Young, 2012).

In a review of the Lake Taupo Nitrogen Trading market Spicer (2017) reports the cap and trade regime has both facilitated land-use change and not hindered market-led change.

5.47 Methods of allocating emission rights

Whatever method is chosen to initially allocate emission rights there will be individual farms that benefit and those that are penalised. This is unavoidable. But we often see instances where externalities occur that benefit some and hinder others. This is a fact of running any business. Therefore while it is important to carefully consider which method is chosen, and the level of allocations, it must be remembered that no method is perfect and every method will result in winners and losers.

Often to resolve the initial allocation issue and get sufficient stakeholder buy-in to the programme, it is useful to have funding available to buy back some nutrient applications so that the initial target can be met with relatively little cost to individuals. This approach was used relatively successfully in the fisheries individual transferable quota (ITQ) situation where some stocks were over fished and the total allowable catch set was lower than existing catch. Voluntary buy backs avoided either cutting everyone's catch or requiring decisions about who would be excluded from the fishery. This was funded by central government. Similarly, for the Lake Taupo case, a fund has been established to ease the initial introduction of the nutrient cap (Kerr, Lauder & Fairman, 2007).

Land use capability

This method considers the capability of the land and allows a greater nutrient loading for the more productive land classes.

Land Use Capability Classification is a system in use in New Zealand since the 1950s to try and achieve sustainable land development and management on farms. The system classifies all of New Zealand's rural land into one of eight classes, based on its physical characteristics and attributes. Class 1 land is the most versatile and can be used for a wide range of land uses. Class 8 land has a lot of physical limitations, it may be extremely steep, and not generally suitable for arable, pastoral or commercial forestry use.

The advantage this method has over other methods is that the overall economic returns for the region as a whole will be greater if there are less restrictions on the most capable land, as the productive from this land will be greater than that from less productive land – assuming same level of inputs (such as fertiliser). As the allocation is linked to the land (rather than the land use) there is no incentive to change land use, or increase loading ahead of allocations.

The Tukituki catchment (Hawkes Bay) has adopted the land use capability method for allocating nutrients.

Equal allocations

Emissions are allocated on a per hectare basis with no consideration for land capability or current use. The advantage of this is that on paper this method appears fair. However it doesn't consider the economic implications as it will result in large costs to the farms with the highest level of production and effectively gift this to the poorer quality farms.

Industry benchmark

This method takes into consideration the differing level of nutrient outputs by industry. It works on the basis of what is good practice for a particular industry and sets the limit accordingly. The advantage of this method is that is allows a high level of output for the industries that require it while still penalising the excessively high emitters. The disadvantages is that it does not take into consideration what is an acceptable level of nutrient loading for a particular catchment. It also locks land into its current use therefore penalising those on high quality underdeveloped land.

Grand parenting

The grand parenting approach allocates nutrients based on current output. This approach tends to ease the burden on those who mitigate more – it does not disadvantage farmers who have high baseline nutrient loss due to factors outside their control (Timar, 2013). Grand parenting of freshwater allocations (either of abstractions or discharges) does not assist transformation but tends to cement the status quo (Waikato Regional Council, 2017).

Disadvantage of using industry benchmarks or grand parenting methods is that it can encourage farms to lift their level of emissions ahead of any restrictions being put in place.

Grand parenting was the method used in the Lake Taupo catchment to allocate nitrogen allowances.

5.48 Measuring emissions with OVERSEER®

Where it is not practicable to measure diffuse discharges directly, the requirements of the National Policy Statement for Freshwater Management will generally require some form of catchment and source nutrient load modelling to provide a basis for identifying and implementing appropriate management measures to achieve water quality objectives (Freeman et al., 2016).

OVERSEER® Nutrient Budgets (Overseer) is a computer software model that is being used to provide estimates of annual losses of nitrogen and phosphorus at the farm level.

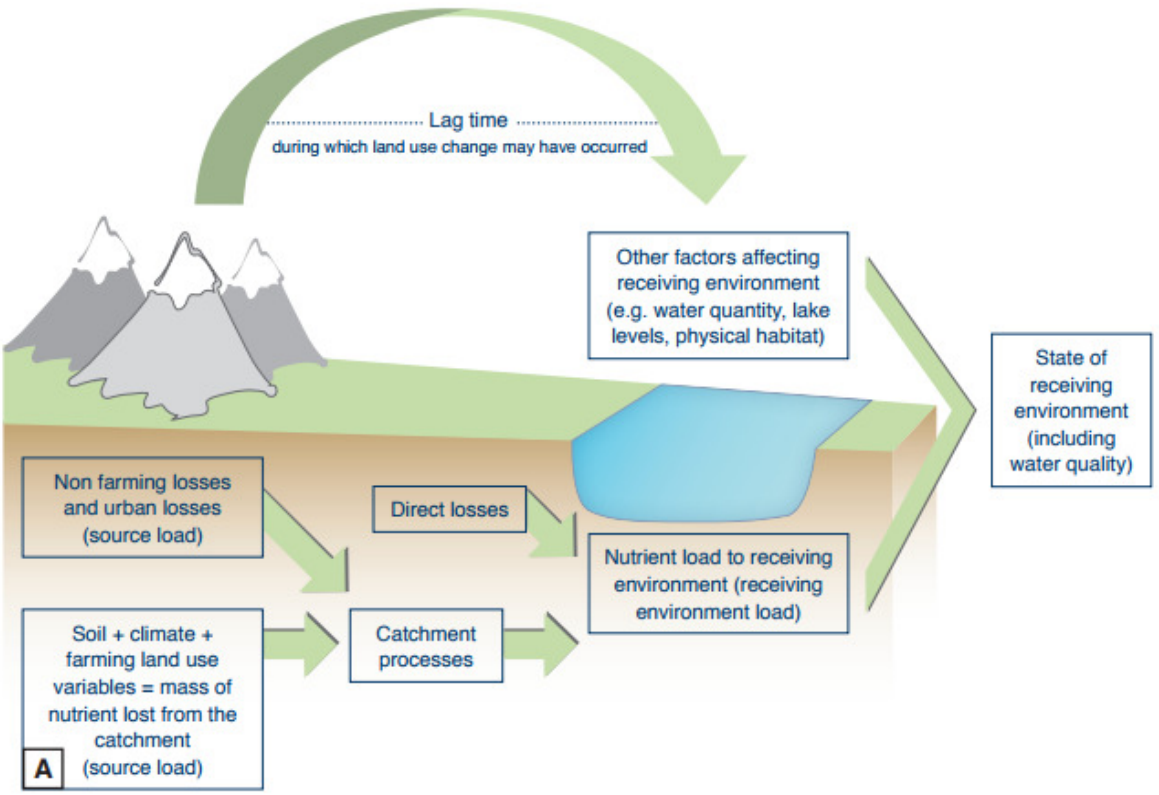
Modelling nutrient losses is really the only practical solution where it is not possible to accurately measure actual nitrogen and phosphate losses at an individual farm level.

Overseer can model farm-specific nutrient budgets for seven nutrients (N, P, K, S, Ca, Mg, Na), acidity, and greenhouse gas emissions on a per product and per hectare basis (Wheeler & Shepherd, 2013).

The OECD says New Zealand is uniquely positioned to cap and manage diffuse pollution outputs with Overseer - a system that models the flow of nutrients on a farm and estimates the amount of nutrients lost through air, soil and across the land (OECD, 2017).

There is no single correct approach to managing the impacts of land use on water quality, and Overseer may be used in different ways within these different approaches. Providing the assumptions, limitations and principles are taken into account, Overseer is suitable to provide estimates of nutrient loss for use in the implementation of the National Policy Statement for Freshwater Management 2014 (Freeman, et al., 2016).

Figure 5: Where Overseer fits into the relationship between losses of nutrients from a catchment and water quality



Source: Freeman Environmental Ltd & the Bay of Plenty Regional Council

Simplified conceptual relationship between losses of nutrients from the catchment and the state of receiving environment water quality (groundwater, rivers and lakes), 'A' indicates where a model such as OVERSEER can be used to estimate the farming land-use portion of the source nutrient load.

Overseer does have its limitations which must be acknowledged and taken into consideration when planning policy that relies on the model for regulation and monitoring purposes.

These include:

- The programme assumes best practice is adhered to so there could be significant gains to be made on some farms just by adhering to best practice – such as the timing and quantity of nitrogen fertiliser applications.
- The programme is based on long term averages and is now being used for short term modelling.
- The variation in the model - between what is modelled and what actually happens – is significant at +/- 20-30%.
- As the model evolves new versions are released. Different version of the model can give significantly different results at the individual farm level so this must be considered when designing policy that relies on Overseer.

It has also been suggested that Overseer is not yet sufficiently proven as an accurate measure of phosphate runoff and therefore caution must be taken if this model is used for regulating phosphate discharges.

Overseers' N leaching model has a significant amount of validation, whereas the P loss model is based on a calibration process (Wheeler & Shepherd, 2013).

Like it or not, Overseer has become the standard tool for nutrient management throughout New Zealand. This programme is not perfect but it is the best we have today for modelling nutrient flows in agricultural systems (McNae, 2016).

5.5 Using a market based approach

A market is a medium that allows buyers and sellers of a specific good or service to interact in order to facilitate an exchange.

Markets can be physical market – such as a sale yard where livestock are traded, or an online platform – such as TradeMe. Formal markets exist – such as a regulated exchange for example NZX – as do informal markets.

Markets can be public, where anyone can participate, or private, where trading is limited to a select group. The Fonterra Shareholders Market is an example of a private market as participation is primarily restricted to farmer shareholders[2].

Markets vary considerably in form but they typically provide similar functions.

The Business Dictionary defines the functional attributes of market as:

- determining price,
- communicating price information,
- facilitating deals and transactions, and
- effecting distribution.

Markets to trade nutrients are not a new concept. Nearly 50 years ago effluent trading systems were proposed (Dales, 1968).

Selman et al. (2009) identified 57 trading systems focused on water quality worldwide.

The OECD recommends New Zealand authorities should expand the use of economic instruments to internalise environmental and opportunity costs, promote innovation and encourage efficient use of water quantity and quality (OECD, 2017).

Greenhaugh et al. (2010) says in theory, environmental markets can provide the same or better environmental protection at lower cost to business than regulation. While Tietenburg (2006) goes a step further stating "Environmental markets have some key theoretical advantages over stand-alone regulation or price based economic instruments, especially in efficiency and cost-effectiveness in improving environmental quality and meeting environmental goals".

A trading scheme is desirable, as it encourages mitigation to occur where it is most cost effective. Profit-maximising landowners will mitigate as long as it costs less than the allowances they would otherwise have to hold (Anastasiadis et al, 2011).

Transition from a predominantly regulatory system to one where rules complement and support other policy options (eg economic instruments and persuasive methods) for behaviour change (Waikato Regional Council, 2017).

The success of existing programmes trading nutrient emissions proves the concept is viable in a New Zealand setting.

In a review of the Taupo Nitrogen Market, Kerr et al.(2015) concludes it is technically feasible to include non-point sources within a cap and trade water quality market, that such a market can function, and that once property rights are clearly established, the additional cost of allowing trading is low.

Greenhaugh et al. (2010) defines a successful environmental market as one that besides meeting its environmental goal, lowers the compliance costs for the regulated participants, provides incentives to innovate, and lowers regulator costs - administration, monitoring and enforcement

Market based instruments, and specifically tradable allowance regimes, are one important part of the potential tool kit to address these issues. (Kerr, Lauder, & Fairman, 2007).

[2] In addition to farmer shareholders the Fonterra Shareholders Market also allows trading by Fonterra as well as a market-maker.

Access to a wider range of policy options would allow each to do what it is designed for (eg use regulation to determine the size of the allocation in each Freshwater Management Unit and then use a combination of market instruments and information opportunities to alter behaviour to decide who gets what, where and for how long) (Waikato Regional Council, 2017).

5.51 Pricing promotes efficiency

Market-based approaches are, in theory, an effective way of allowing resources such as water to move to their 'highest value' uses. Transfers and trading of water between users, combined with a regulatory approach, have the potential to improve the value obtained from water (Waikato Regional Council, 2017).

A trading market can facilitate an efficient mitigation effort both because mitigation efforts are done in the most effective way at each point in time and because the market creates incentives to find and adopt new technologies and land management methods. (Kerr, Lauder, & Fairman, 2007).

Pricing can be focussed on efficient allocation and can include both abstracted volume and volume required to assimilate contaminants (effluent strength). Prices can be a highly effective way of providing incentives for water users to use resources more efficiently (Waikato Regional Council, 2017).

An Australian Government financial system inquiry conducted in 2014 found an efficient [market] system allocates scarce financial and other resources for the greatest possible benefit to our economy, promoting a higher and more sustainable rate of productivity, and economic growth.

Efficiency in an environmental market sense requires maximising current costs and benefits of using or extracting natural resources while taking into consideration future costs and benefits, including the intrinsic and existence value of the resources (Anderson, 2015).

When the market fails to allocate the resources efficiently, market failure can occur. An example of this is the creation of externalities which often occurs when clear property rights are absent, as with air and some water resources. Attempts to promote efficiency and bring the market back into equilibrium can be through market options, like economic incentives and disincentives, or the establishment of property rights, or through government intervention (Anderson. 2015).

When no pricing process exists, there is no mechanism to transform technological externalities into pecuniary externalities. Accordingly we do observe [in Canada] striking examples of externalities in water use; stinking streams flow through choice residential areas, and anglers experience a mixture of rage and resignation as their favourite streams are polluted by industrial wastes (Dales, 1968).

By allowing the market to put a price on a natural resource it is then easier to have a more informed and objective discussion around the use of resources.

The ability to price the strength of discharges will allow comparisons between diffuse and direct sources, thus integrating urban and rural effects (Waikato Regional Council, 2017).

Integrating the environmental impacts of both urban and rural pollutants into one system should make it much more transparent and obvious that we all have a role to play and are jointly responsible for improving the environment.

It also provides a framework where the government, communities or individuals could buy nutrient emission rights and set these aside – effectively reducing pollution.

Purchasing water for the environment directly from the water markets simultaneously 'internalises' potentially deleterious third party effects, legitimises the environment as a consumer of water, and presumably instils confidence in the property rights regime for those currently holding water licences (Delforce, Pigram & Musgrave, 1990).

5.52 Challenges of using a market based approach

A market based approach may not address all objectives of a particular catchment, such as it may not account for social costs associated with land use change or effectively deal with excessive nutrient loading in one particular area.

A market based approach also needs to be supported by rules which can manage what the market can't.

When it comes to the utilisation of natural resources or other environmental quality amenities, it is often difficult to find the equilibrium through mere market pricing since they are not true market goods (Anderson, 2015).

A market based approach is often feared due to a lack of understanding. This means that only those who understand the market are likely to participate.

Syme et al. (1999) concludes "water markets alone are not considered fair or acceptable processes for allocating or reallocating water".

A poorly designed nutrient trading market could have unintended negative consequences.

There is no point controlling one nutrient if increased levels of the other combined with baseline levels will still lead to acute water quality problems. If controlling one of the nutrients would be hard and small changes in its flows would have little effect in the short term, however, it may not be such a priority for control (Kerr, Lauder, & Fairman, 2007).

The link between 'restrictions on how land is used' and the 'value of that land' makes it difficult to price environmental assets - such as nutrient discharges or water rights. There is a general fear that if rights are sold then they may not be able to be purchased at a later date and therefore will reduce the underlying value of their land.

In the case of the Murray River water trading Crase, O'Reilly & Dollery (2000) advise only the most desperate offer permanent water for sale and many hold permanent rights for speculative reasons.

The Lake Taupo Protection Trust took the view that when they were purchasing nitrogen discharge rights that they were also compensating land owners for future lost earnings due to the restrictions this imposed on land use.

It is important to remember that the party is not only selling nitrogen but also the rights to the use of the land in perpetuity which for private land in particular may have a significant effect on their capital value (Lake Taupo Protection Trust, 2015).

As one participant put it "*It's as if I have a 5 bedroom house and you are buying 3 bedrooms that can't ever be used again….what is my house worth?*

The agreements achieved therefore had (in the view of the Lake Taupo Protection Trust) to be sufficiently attractive to compensate for the effects of the restrictions applied.

5.6 Developing a nutrient emission market

5.61 Clear goal

For any market to succeed it must be clear what the objectives of the market are. This allows rules to be adapted or evolved in a way that meets those objectives rather than the requirements of a particular group.

Market success seems to be linked to highly prescriptive, detailed and carefully thought-through legislation or regulation, which sets an appropriate cap (Greenhaugh et al. 2010).

The challenge is to decide how much time, effort and resources should be invested in policy and system design prior to policies being finalised so that the market has a chance of success versus what can be tweaked along the way. Delays with developing policy make the eventual task of improving environmental standards more difficult due to the further degradation of the environment that could occur in the meantime.

The longer it takes to develop new approaches to allocation, the more difficult it will be for communities to transition to managing within the limits they set and to phase out existing over-allocation (Smith & Guy 2016).

The more clearly defined a goal is the greater the chance of achieving it in an efficient manner.

A framework or 'constitution' for reviewing the effectiveness of the market in achieving its' goal(s) is a useful way to assess whether any changes to the market or to the market rules are required.

The 'constitution' needs to define who participates in making decisions, how decisions are made, how the system is monitored and evaluated, which aspects of the system can change without a 'law' (or rule) change, and what structure is placed on the changes (Kerr, Lauder & Fairman, 2007).

There is a trade-off between explicit regulation where goals, rights and obligations are clear and well enforced and a set of regulations where the difficult issues are still unresolved, transaction costs are high because of uncertainty, the environmental goal is both less clear and less likely to be achieved, and any gains that are achieved are likely to be achieved at a relatively high cost (Kerr, Lauder, & Fairman, 2007).

Many of the issues that must be addressed to implement and effect nutrient trading must also be addressed for other effective regulations. Many of the challenges presented as barriers to using nutrient trading – such as setting a specific monitorable cap on emissions; or determining who should bear the cost of abatement effort – also apply to any other comprehensive regulation; they are simply more transparent in a trading regime (Kerr, Lauder, & Fairman, 2007).

5.62 Industry consultation and education

Researchers and analysts involved in the establishment of market-based incentives in other areas (e.g. fisheries quotas in New Zealand, sulphur dioxide emissions trading in the U.S.) feel that part of stakeholder resistance to policies comes from lack of understanding of key technical issues, whether they relate to the seriousness of the problem or the real effects of a trading programme (Kerr, Lauder, & Fairman, 2007).

Education and promotion pays a large part in the success of any market. There is a need to provide education relating to both the underlying problem as well as the potential solutions. This must be done in a systematic manner. There is no point educating about the intricacies of how a nutrient trading program could work if the audience lacks knowledge or refuses to accept there is an underlying problem.

There was, and still is, a considerable resistance toward both taxes and tradable quotas, often laced with moral indignation. This is especially so for tradable emission quotas (Braatena, Brekke, & Rogebergc, 2015). It can be particularly challenging to educate within a public meeting environment when the level of knowledge in the audience varies tremendously. It must also be acknowledged that different learning styles exist. The style preferred by the facilitator won't be the style that best suits the audience. A more 'hands-on' learning experience may make it easier for potential market users to come to grips with how a trading system could work.

This is the approach recommended by (Kerr, Lauder & Fairman, 2007) who suggest the need to create a receptive environment in the set-up phase (i.e. before the market is operational) so the policy is politically attractive and all key stakeholders engage constructively to improve the market design.

The Waikato Regional Council is mindful that putting a price on water would also raise important questions of equity and difficult questions such as these will need to be addressed if a trading scheme is to have a chance of succeeding.

5.63 Government support

Successful environmental markets typically require participation by different levels of government, and hence good relationships among all levels of governance. Greenhaugh et al. (2010) suggest that greater centralisation of rule development, market design and infrastructure is needed to reduce the costs of establishing and operating environmental markets. Less 'reinventing the wheel' in areas which will be consistent across regions such as measurement methodologies, market infrastructure, etc.

It would be possible to develop a single trading platform and/or a single registry which could centralise trading costs. But more pressing is the need to share research, learnings, and knowledge and education materials across central and regional governments, and with industry and external interest groups.

The success of any market also requires ongoing support in terms of regulation, education, and promotion. New markets need to be nurtured.

Giving the opportunity to trade does not mean that trading will necessarily take place in a catchment. Encouraging water allocations to be traded also requires institutional and political support. (Kaye-Blake et al. 2014).

When developing a market it must be clear what the purpose of the market will be, that is, the role the market is expected to perform. The role the market is expected to play must be discussed with potential users of the market so it is clear how the market will operate and identify any limitations of the market. This will then ensure that potential users of the market have realistic expectations of what the market can achieve.

5.7 Designing a successful market

When designing a market it makes sense to draw on the experiences of similar markets operating in other sectors or other geographical locations. We also now have the advantage of drawing on the knowledge gained within the nutrient markets that are operating within New Zealand. The OECD has says lessons can be learned from the Lake Taupo Nitrogen Market – the first diffuse pollution trading scheme in the world (OECD, 2017).

The success of a market is largely determined by its design. The following key design principles were applied in designing the Fonterra Shareholders' Market, are also applicable to market design in general:

- Liquid
- Trusted
- Fungible (i.e. standard units)
- Straight-forward
- Ready (to operate when the industry requires it)
- Contestable

At a textbook level, the design of a tradable nutrient regime is simple: set a cap on emissions; allocate allowances; allow trade; and monitor emissions. In reality, each of these steps is complex and difficult to do well (Kerr, Lauder, & Fairman, 2007).

The international literature on permanent water markets points to at least six factors which seem to have impeded the development of permanent water markets. These included unclear or poorly defined property rights to access the resource, unreliable and variable supply, infrastructure impediments, excessive transaction and transfer costs, hoarding behaviour and speculation, and cultural or sociological attributes that limit market participation (Crase, O'Reilly, & Dollery, 2000).

5.71 The need for clear property rights

In order for something to be traded it must firstly be clear what is available to trade. Clear property rights must exist and be recorded in a central place.

Market-like trading programs for water quality management begin with enforceable limits on the amount of the pollutant allowed in a watershed [catchment]. Properly designed market-like trading programs then create incentives for discourages to reduce nutrient control costs over time by making pollution prevention innovations (Shabman & Stephenson, 2007).

Some policies, such as a non-tradable cap, could be considered precursors to a potential trading regime; they have many common requirements. The most difficult part of establishing a trading regime is defining and creating the property rights to be traded and this must also be addressed in any capped regime (Kerr, Lauder, & Fairman, 2007).

Dales (1968), noted that the absence of an ownership-rental system for water in Canada has meant that water use has in fact been determined by such things as historical priority, gall, and force and fraud; it cannot be otherwise when property rights do not exist and when the price for the use of a valuable asset is zero.

The major barrier to most trading systems is the need to explicitly define and allocate property rights (Kerr, Lauder, and Fairman, 2007).

An efficient market in tradable water entitlements is possible only where the property rights associated with those entitlements are non-attenuated. This implies that the right to use water must be clearly specified, enforceable and enforced, exclusive, and capable of voluntary transfer (Pigram & Musgrave, 1998).

Where effective arrangements for water entitlements, water accounting and water allocation do not exist, it is very unlikely that sustainable water trading can be meaningfully established. Even where these conditions are met, sustained effort is required to achieve a successful water market (Turral et al., 2005).

Register

Any cap system, with or without trading, must record individual landowners' allowable cap and monitored/modelled levels of nutrient applications (Kerr, Lauder & Fairman, 2007).

A register system needs to be sophisticated enough to record ownership at each point in time, as well as recording any excess of nutrient allowances that are held over and above the modelled usage level.

A trading programme is even more dependent on the integrity of this system because mistakes can lead to illegitimate trades (Kerr, Lauder & Fairman, 2007).

5.72 Standard units

Units that are traded must also be fungible (or identical). This is relatively easy if just one nutrient is being traded. If a trading scheme is designed that includes more than one nutrient, such as a scheme where the unit of measure may be the volume of water that is being polluted or used, then defining what the unit is becomes more complex.

For nutrient emission trading - if usage is being defined by modelling the output - then it may become necessary to define the version of the model that is being reviewed or include a way to calibrate the system to account for model changes.

5.73 Market liquidity – making it easy to trade

Liquidity is a market characteristic that assures investors that they can promptly purchase or dispose of stock at a price closely related to the market's best estimate of the present value of the future income stream that the stock will generate for investors (Klein & Coffee, 1986).

Market liquidity comprises of three elements, identified by Macey & Kanda, 1990. The first element is simply that investors must be able to buy or sell stock promptly. Second, liquidity requires that the price at which investors sell their shares be rationally related to the market's existing estimation of the firm's earnings prospects. In an illiquid market, the ultimate sales price can be biased downward by artificial conditions, such as the lack of a willing buyer. Finally, the information on stock prices must be produced and disseminated at low cost.

Understanding the current value of something that you wish to trade and the factors influencing the market provides buyers and seller with the confidence to trade.

Exchanges enhance market liquidity because they serve as central producers and disseminators of information. It is not the rules of exchanges that provide this liquidity. Rather, the simple fact that exchanges provide a single centralized forum where securities trading can occur (Macey & Kanda, 1990).

A central trading platform also makes it much easier to locate the other side of the trade, i.e. a buyer or seller. Think how successful TradeMe has been in connecting buyers and sellers.

[On an exchange] traders obtain instantaneous, continuous bid-and-asked quotations for the stocks listed on the system, thus making it possible for central information processing to occur. In addition, the search costs historically associated with trading over-the-counter[3] stock have been eliminated, since computer screens supply the identification of those market participants willing to consummate trades (Loll & Buckley, 1981).

Transaction costs tend to be lower when trading occurs through a regulated market than off-market trading. The time it takes to find a trading partner is typically more efficient, and legal costs are typically reduced as standardised deals can be made.

A cost associated with contracting within the firm is the cost of forming contracts and the cost of enforcing those contracts (Easterbrook, F., 1985).

[3] An over-the-counter trade is done directly between two parties without an exchange supervising the trade or acting as in intermediary.

Exchanges provide benefits to listed firms by supplying standard contract terms and enforcement services that reduce the costs associated with intra-firm contracting (Macey & Kanda, 1990).

Size of market

The potential size of the market is also a factor which can determine the success of the market. The larger the market the greater the potential for more participants to be involved in the market and therefore improve the potential for liquidity.

Nutrient discharge trading within New Zealand so far has been limited to a single nutrient within a single catchment (also referred to as 'freshwater management units'). Widening the scope to cover numerous nutrients, or water use in general, or to cover numerous catchments would increase the potential size of the market but also increase the complexity of any trading system.

The Waikato Regional Council is looking to implement a strategy which integrates both water usage and water quality. This could potentially enlarge the size of the total market, although it is not yet decided if the strategy will involve trading or not.

The new [Waikato Regional Council] freshwater strategy recognises the amount of water left in waterways and its quality are inextricably linked as less flow means a lower ability to safely assimilate contaminants such as nutrients, sediment and bacteria. Potential pricing tools included water take volume-based consent charges or local "taxes". A market for trading of water use permits was another option [being considered] (Waikato Regional Council, 2017).

The market size, and therefore potential liquidity, can be increased by opening the market to those not directly involved with the underlying assets. But opening the market can result in fears that 'outsiders' will end up controlling the market.

In the case of the Lake Taupo Nitrogen market ownership of allowances has also been restricted to landowners in the catchment, which will limit the ability of any outside investors to accumulate market power (Kerr, Greenhalgh & Simmons, 2015).

Some markets also have rules on 'position limits' i.e. a limit on the portion of the market that can be held by one person or organisation. The purpose of position limits is to limit the influence that a person/organisation can have on the market.

Role of market makers

The purpose of a market maker is to provide the market with more liquidity, that is, make it easier to buy or sell. A market maker as a firm that stands ready to buy and sell stock on a regular and continuous basis at a publicly quoted price

Markets benefit from market makers (algorithmic traders) that maintain constant open interest on every asset, providing liquidity that may be hard to support organically (Othman & Sandholm, 2010).

Some market have formal market makers which are paid a fee to assist the market to operate, but the revenue gained by market makers is primarily derived from the difference between the price which they purchase and sell at.

The market maker adds to the stability, liquidity and transparency (i.e. price discovery mechanism) of financial markets and is therefore a desirable participant in emerging markets (IOSCO, 1999).

In the case of the Lake Taupo Nitrogen the Lake Taupo Protection Trust effectively acts as a market maker. The trust was established with NZ$81.5 million in funding from central (45%), regional (33%) and local governments (3322%) (Environment Court 2011).

The trust is a public fund which received contributions from local, regional and national government.

The Lake Taupo Protection Trust was tasked with using its funding to purchase and permanently retire nitrogen discharge allowances (NDAs) from farmers to reduce the size of the cap by the required 20 percent (Duhon, Kerr & McDonald, 2014).

To June 2014, the Trust has executed 23 trades and there have been 12 other NDA trades between regulated farmers (Kerr, Greenhalgh & Simmons, 2015) i.e. 66% of the trades. Therefore it is clear that the presence of the trust in the market has enabled more trading to occur than what would have occurred otherwise.

Role of speculators

Speculators provide a similar role to market makers in the sense they add liquidity to the market. The people (or organisations) aim to make a profit from the market by buying at a lower price than they sell at.

Investopedia defines a 'speculator' as a person who trades derivatives, commodities, bonds, equities or currencies with a higher than average risk in return for a higher-than-average profit potential.

Speculators benefit a market by assuming risk that other market participants do not want. Due to their willingness to take on risk they will tend to buy when no one else wants to buy, or sell when no one else wants to sell.

Normally, speculators operate in a shorter time frame than a traditional investor (Investopedia). As speculators often want to trade frequently they tend to avoid markets with very low levels of liquidity. If speculators do join a market they will add further liquidity.

Industry support

For any market to be successful it has to gain the trust and the support of the industry which it aims to serve. Having industry participants involved in the design of the market and consulted on potential rule changes will help to build trust and ultimately increase trading potential.

In the case of Rotorua Te Arawa Lakes Programme an advisory group consisting of 15 members from different sectors was formed in 2012 to provide input, advice and recommendations on the development of new rules and the incentives to help landowners meet them.

Price transparency

Price transparency is defined as "the degree to which market participants know the prevailing prices and characteristics or attributes of goods or services on offer" (Clemons 2002).

Markets which publish trading prices or bid and offer prices generate price transparency. This price transparency helps the market function as it providers both buyers and sellers with confidence that they are receiving a 'fair' price.

If buyers and sellers do not know what prices are, then some mutually agreeable trades will fail to occur, thus creating inefficiencies (Austin & Gravelle, 2007).

There is no price transparency (published trading price) in the Lake Taupo Nitrogen market. Sellers have been highly reliant on pricing offered by the Lake Taupo Protection Trust - the largest buyer in this market.

The trust has established a standard price of approximately NZ$400 per kgN permanently reduced. The trust pays this over time, which with discounting is estimated to equate to an upfront price of roughly NZ$300/kg (Duhon, Kerr & McDonald, 2014).

The trading price in 2012 was around $300 per kilogram of nitrogen permanently removed. This was largely determined by the Trust's trades so does not necessarily reflect the long-run value of nitrogen in the catchment (Kerr, Greenhalgh & Simmons, 2015).

How a market is designed will impact on its success. For markets to be successful they need to be supported by those who can potentially use the market. Access to current price information is a key factor in the success of a market. This information in itself is often valued and can trigger interest in the market by potential users. The larger the potential size of the market then greater opportunity there is for trades to occur. Markets that are restricted to a small user group may at times find it difficult to locate a trading partner. This problem can be solved by including market makers or by opening markets to speculators. Whether the market is open or restricted depends of the objective of the market.

5.8 Ensuring the market remains relevant

Adaptability

Regulations and policies need to adapt to changing circumstances in the market. For a product to successfully trade the market must be relevant and adapt as required. However the market must also provide participants with certainty that changes made to the market won't negatively impact them. Therefore regulatory changes should only be made after consultation with market participants and with adequate warning.

No regulation is perfect when first created. This is particularly true of environmental regulations that need to deal with changing social and environmental circumstances and new knowledge about human-environment interactions. Therefore, environmental governance structures should allow the evolution of the regulatory system to occur in an effective, fair and efficient way (Kerr, Lauder & Fairman, 2007).

The accuracy of measuring the impact various farming practices have on the environment will improve over time as science and research evolves. Therefore changes may have to be made to regulations or policies to incorporate these changes.

It is inevitable that future rule changes will have the potential to negatively impact some market participants. But so long as rule changes are done in a manner that is aligned with the goal or constitution of the market then this should not been seen as an impediment to evolving market rules.

Keeping markets remain relevant to participants is key in ensuring longevity of any market. This may require several rule changes over time as changes will occur that could not be realistically anticipated when the market was initially formed.

6. Conclusions & Recommendations

- A trading system to allocate nutrient discharge allowances can be used as part of a wider system for managing water quality. A trading system alone is not a viable solution. It must also be supported by policy and regulations that provide the underlying certainty for a trading system to operate effectively.
- It is possible to have a trading system that would manage both urban and rural discharges, including multiple nutrients, but this would be more complex and more difficult to introduce than a system for a single nutrient.
- A market to trade nutrient allowances is an efficient economic tool to reallocate allowances between emitters. A market based system allows you to put a price on the environment and can be used to reduce pollution levels by reducing the supply of nutrient discharge allowances (by buying up units).
- If a trading system is deemed to be a suitable economic tool to be used to manage nutrient emission then careful thought must be given to the design process. The market must be designed with the farmer and other potential users in mind and industry must be consulted through the development phase. The market should be built in a manner which promotes trust amongst potential users so that liquidity can develop. Price transparency is important to promote confidence amongst market participants.
- Education throughout the development phase and even once the market is trading is required to establish a successful market. Markets need to be nurtured.
- A precursor to any nutrient trading program is the establishment of clear property rights in the form of nutrient discharge allowances. If a cap has not been placed on nutrient emissions at the regional or catchment level and then allocated amongst emitters it is not possible to have a trading system. At present many councils are grabbling to develop the policy and regulations best suited to their region, that form the underlying requirements for any allocation programme.
- At the national governance level clear bottom lines have been developed and it is up to regional governance to implement these. In many regions and catchments it is not yet clear whether nutrient emissions are already too high due to no regulation or over allocation of nutrient allowances. It is difficult to design an appropriate solution when there is a lack of clarity as to the scale of the problem. A lack of support from central government to regional governments is also slowing the potential pace of the development of policies and regulations at a regional level.
- Waiting for perfect information will only delay decisions that will inevitably have to be made. There are valid concerns that any further delay in implementing solutions will make it even hard to get rivers to swimmable standards.
- During the research process undertaken for this report it became apparent that a vast amount of research has already been completed on appropriate policies and regulations to manage water quality. However it appears that only a small pocket of people have a high level of knowledge of this topic. This makes me wonder whether a lack of knowledge that spans both the environmental sector and the agricultural sector is what is holding back environmental solutions being implements. This is a topic which I recommend further study is undertaken as it is outside the scope of this report.

7. References

Anastrasiadis, S., Nauleau, M., Kerr, S., Cox, T., Rutherford, K., "Does complex hydrology require complex water quality policy? NManager simulations for Lake Rotorua", Motu Working Paper 11-14. Motu Economic and Public Policy Research, December 2011

Anderson, D., "Supply & Demand – How markets work", The Environmental Literacy Council, 2015

Austin, D.A., and Gravelle, J.G., "Does Price Transparency Improve Market Efficiency? Implication of Empirical Evidence on Other Markets for the Health Sector", Congressional Research Service, July 2007

Australian Government the Treasury, "Financial System Inquiry – Final Report", Nov 2014

Bagshaw, C.S., Thorrold, B., Davison, M., Duncan, I.J., Matthews, L.R. "The influence of season and of providing a water trough on stream use by beef cattle grazing hill-country in New Zealand", Applied Animal Behaviour Science, 2008.

Barns,S. and Young,J. "Cap-and-trade of diffuse emissions of nitrogen in Lake Taupo Catchment. Reviewing the policy decisions and the market" Waikato Regional Council Technical Report 2013/34, July 2012

Bisley, A. "NZ urgently needs a comprehensive plan for cleaning up lakes and rivers', Dominion Post, April 2016

Bond, T.A., Sear, D., Edwards, M., "Temperature-driven river utilisation and preferential defecation by cattle in an English chalk stream", Livestock Science Journal 146, Feb 2012

Braaten R.H., Brekke, A., and Rogeberg,O. "Buying the right to do wrong – An experimental test of moral objections to trading emission permits", Resource and Energy Economics Journal, July 2015

Chapman, D., Macdonald, K., Dalley, D., Sheppard, M., Monaghan, R., Edwards, G. "Principles from Pastoral 21: Optimising dairy system strategies to meet nutrient limits", DairyNZ Technical Series Issue 33, March 2017

Clemons, E.K., Hann, I.H., and Hitt, L.M. "Price Dispersion and Differentiation in Online Travel: An Empirical Investigation," Management Science (48:4), April 2002

Close, M., Dann, R., Ball, A., Savill, M., Pirie, R., & Smith, Z. "Microbial groundwater quality and its health implications for a border-strip irrigated dairy farm catchment, South Island, New Zealand." Journal of water and health, 6 (1), 2008

Clothier, B., Mackay, A., Carran, A., Gray, R., Parfitt, R., Francis, G., & Green, S. "Farm strategies for contaminant management". A report by SLURI, the Sustainable Land Use Research Initiative for Horizons Regional Council, 2007

Coghlan, S. "An Evaluation of Voluntary Environmental Schemes used by the Dairy Industry in Canterbury, New Zealand", Lincoln University, 2015

Crase,L.,O'Reilly,L., and Dollery,B., "Water markets as a vehicle for water reform: the case of New South Wales", The Australian Journal of Agricultural and Resource Economics, 2000

Dales, J.H. "Land, Water, and Ownership", University of Toronto, Canadian Journal of Economics, Vol.1, No.4, November 1968

DairyNZ, "DairyNZ Annual Report 2016/17 Summary", DairyNZ, Oct 2017

DairyNZ, "Land management on Waikato dairy farms – Managing land to reduce sediment and phosphorus loss", March 2016

DairyNZ "Sustainable Dairying –Water Accord – Three years on", DairyNZ, March 2016

Dawson, A. N. “How to Defend (and Attack) the Resource Management Act: The Principled Consequences of Reducing Public Participation in Environmental Decision-Making”, University of Otago, Oct 2013

Delforce,R., Pigram,J., and Musgrave,W., “Impediments to free market water transfers in Australia” ” Transferability of Water Entitlements: An International Seminar and Workshop, Centre for Water Policy Research, Armidale, 1990

Donnison, A., Ross, C., & Thorrold, B. “Impact of land use on the faecal microbial quality of hill- country streams”, New Zealand Journal of Marine and Freshwater Research, 2004.

Duhon, M., Kerr, S., McDonald, H., “Nitrogen Trading in Lake Taupo – An analysis and Evaluation of an Innovative Water Management Policy”, Motu Working Paper 15-07, Motu Economic and Public Policy Research, June 2015

Easterbrook, F.H.,”Insider Trading as an Agency Cost Problem, in Principals and Agents: The Structure of Business”, 1985.

Environment Guide, www.environmentguide.org.nz, Updated Jan 2015, Accessed Oct 2017

Environment Court, “Final decision of the Environment Court in the matter of Carter Holt Harvey Ltd. v Waikato Regional Council” NZEnvC 163, 2011.

Freeman, M., Robson, M., Lilburne L., McCallum-Clark, M., Cooke, A., & McNae, D., “Using OVERSEER in regulation - technical resources and guidance for the appropriate and consistent use of OVERSEER by regional councils”, Report prepared by Freeman Environmental Ltd for the OVERSEER Guidance Project Board. August 2016.

Gluckman, P., “New Zealand’s fresh waters: Values, state, trends and human impacts”, Office of the Prime Minister’s Chief Science Advisor, April 2017

Godin, S., “Seth’s Blog – Unbridled”, September, 2017

Greenhaugh, S., Walker, S., Lee, B., Stephens, T., Sinclair, R.J., “Environmental markets for New Zealand: the barriers and opportunities”, Landcare Research Science Series No. 40, Manaaki Whenua Press, Lincoln, 2010

Harris, B., “Dairy industry’s next decade to focus on environmental practice”, DairyNZ press release, Oct 2017

International Dairy Federation, Press Release, 30 October 2017

International Organisation of Securities Commissions (IOSCO), “The influence of market makers in the creation of liquidity”, Emerging Market Committee, IOSCO, May 1999

Kaye-Blake, B., Schilling, C., Nixon, C. and Destremau, K., “Water management in New Zealand A road map for understanding water value”, NZIER public discussion paper, March 2014

Kerr,S., Greenhalgh,S., and Simmons,G., “The Taupo Nitrogen Market: The world’s only diffuse source trading programme” Motu Economic and Public Policy Research Trust. Note 20, 2015

Kerr, S., Lauder, G.,& Fairman, D., “Towards Design for a Nutrient Trading Programme to Improve Water Quality in Lake Rotorua”, Motu Working Paper 07-03, March 2007

Klein, W., and Coffee,J., “Business Organization and Finance”, 1986

Lake Taupo Protection Trust, “Status report on Completion of nitrogen contracts to meet project target”, June 2015

Land and Water Forum, “The Fourth Report of the Land and Water Forum”, Land and Water Trust, November 2015

Larned,S.T., Snelder,T., and Unwin, M.J. “Water quality in New Zealand rivers: current state and trends”, NZ Journal Marine and Freshwater Research, 50(3), 2016

Loll, L. Jr., and Buckley, J.G., “The Over-the-Counter Securities Markets” 4th edition, 1981

Macey, J.R. and Kanda, H., “The Stock Exchange as a Firm: The Emergence of Close Substitutes for the New York and Tokyo Stock Exchanges”, Cornell Law Review, Faculty Scholarship Series. Paper 1720, July 1990

Mackle, T., “DairyNZ: Dairy ready for a transformational shift”, DairyNZ Press Release, Oct 2017

McNae, D., “Overeseer – Key Consideration in using for Regulation”, Lake Taupo Monitor Farm Programme, Beef + Lamb New Zealand, 2016

Menneer, J.C., Ledgard, S.F., Gillingham, A.G., “Land use impacts on nitrogen and phosphorous loss and management options for intervention”, Environment Bay of Plenty, 2004.

Ministry for the Environment, ”A guide to Identifying Freshwater Management Units under the National Policy Statement for Freshwater Management 2014”, Ministry for the Environment, June 2016

Ministry for the Environment, “Clean Water”, NZ Government, February 2017

Ministry for the Environment. “National Policy Statement for Freshwater Management 2014 (amended 2017)”, NZ Government, Aug 2017

Ministry for the Environment, “Option and existence values for the Waitaki Catchment”, Ministry for the Environment, Jan 2005

Ministry for the Environment, “Update of water allocation data and estimate of actual water use of consented takes 2009-10”, Ministry for the Environment, November 2010

Ministry for the Environment & Stats NZ, “New Zealand’s Environmental Reporting Series: Our fresh water 2017”, Ministry for the Environment & Stats NZ, April 2017

Minnesota Pollution Control Agency, “Nutrients: Phosphorus, Nitrogen - Sources, impact on water quality”, May 2009

Monaghan, R. M., Wilcock, R. J., Smith, L. C., Tikkisetty, B., Thorrold, B. S., & Costall, D., “Linkages between land management activities and water quality in an intensively farmed catchment in southern New Zealand”, Agriculture, Ecosystems & Environment, 2007

New Zealand Business Council for Sustainable Development. “A best use solution for New Zealand’s water problems”, New Zealand Business Council for Sustainable Development. 2008

NZ Immigration “NZ Now website” www.new zealandnow.govt.nz accessed October 31, 2017

OECD, Environmental Performance Review New Zealand 2017”, OECD, 2017

Ongley, E.D. “Control of water pollution from agriculture”, Food and Agriculture Organization of the United Nations, Natural Resources Management and Environment Department, 1996

Oram, B. “Total phosphorus and phosphate impact on surface waters”, Water Research Centre. 2014

Othram, A. and Sandholm, T., “A practical liquidity-sensitive automated market maker”, Carnegie Mellon University, New York, June, 2010

Parliamentary Commissioner for the Environment. “Water quality in New Zealand: Land use and nutrient pollution.” Parliamentary Commissioner for the Environment. 2013

Parliamentary Commissoner for the Environment, “Water quality in New Zealand: Understanding the science”, Parliamentary Commissioner for the Environment. 2012

Pigram, J., and Musgrave, W., “Transferability of water entitlements in Australia” paper presented at the Australian Committee on Irrigation and Drainage Conference, Sale, August 1998

Puckett, L. J. “Identifying the Major Sources of Nutrient Water Pollution”, American Chemical Society, Sept 1995

OECD, “Environmental Performance Review New Zealand 2017”, OECD, 2017

Selman, M., Greenhalgh, S., Branosky, E., Jones, C. and Guiling,J., “Water Quality Trading Programs: An International Overview,” WRI Issue Brief: Water Quality Trading No. 1, World Resources Institute, Washington DC, 2009

Shabman, L. and Stephenson, K. “Achieving nutrient water quality goals: bringing market-like principles to water quality management”, Journal of the American Water Resources Association, Vol43, No.4, August 2007

Smellie,P., “EDS: Water conference could set reform back years”, AgriHQ Pulse, Oct 2017

Smith, N. and Guy, N., “Fresh Water: Allocation Work Programme”, Cabinet Paper authorised by Minister Primary Industries and Minister for the Environment, May 2016.

Spicer,A.E., “Assessing the Consequences of the Lake Taupo Nitrogen Trading Programme in New Zealand, Using a Landscape Approach” Lincoln University, 2017

Syme, G.J., Nancarrow, B. E. and McCreddin, J. A., “Defining the components of fairness in the allocation of water to environmental and human uses”, Journal Environmental Management Vol 57, 1999

Till, D., McBride, G., Ball, A., Taylor, K., and Pyle, E., “Large-scale freshwater microbiological study: Rationale, results and risks”, Journal of Water and Health Vol. 6. No.4, Dec 2008

Tietenburg, T.T., “Emissions trading: principles and practices”. 2nd edition. Washington, DC, Resources of the Future Press, 2006

Timar, L. “Allowance allocation in nutrient markets with heterogeneous farmers – The Lake Rotorua catchment”, Motu Economi and Public Policy Research & GNS Science, May 2013

Turral, H.N., Etchells, T., Malano, H.M.M., Wijedasa, H.A., Taylor, P., McMahon, T.A.M., Austin, N., “Water trading at the margin: The evolution of water markets in the Murray-Darling Basin”, Water Resources Research, Vol 41, July 2005

Verstraeten, G., Van Oost, K., Van Rompey, A., Poesen, J. and Govers, G., “Evaluating an integrated approach to catchment management to reduce soil loss and sediment pollution through modelling”, Soil Use and Management Journal Vol. 18 No. 4, 2002

Waikato Regional Council, “Waikato Fresh Water Strategy”, July 2017

Waikato Regional Council, “Freshwater strategy designed to tackle big issues”, Press release, Waikato Regional Council, June 2017

Wheeler, D.M.m and Shepherd, M.A., “Overseer: Answers to commonly asked questions” Report prepared by AgResearch for the Ministry for Primary Industries, February 2013

8. Glossary

Catchment	A catchment is the area of land feeding a river system. All the precipitation within the catchment combines and flows down to form a single interconnected network of water bodies, including streams, rivers, lakes, wetlands, and aquifers.
Diffuse source (or non-point source) pollution	Pollutants that do not come from a single end-of-pipe source, but from many small sources or from a wide area of leaching, runoff, erosion, etc.
Escherichia coli (abbr. E. coli)	A type of bacteria that live in the guts of humans and other animals. Although usually harmless themselves, high levels of E. coli indicate that other pathogens are present.
Externality	A positive or negative effect on a third party not directly involved with the buyer or seller of the transaction.
Freshwater management unit	A water body, multiple water bodies or any part of a water body determined by the regional council as the appropriate spatial scale for setting freshwater objectives and limits and for freshwater accounting and management.
Leaching	Process by which pollutants in and on soil are dissolved by rain or irrigation water and carried down into groundwater.
Liquidity	Market liquidity is a market's ability to purchase or sell an asset without causing drastic change in the asset's price.
Market maker	A "market maker" is a firm that stands ready to buy and sell stock on a regular and continuous basis at a publicly quoted price
Nitrogen	A chemical element, symbol N. Common forms of nitrogen in water include ammonia and nitrate. 'Nitrogen gas' N^2 also makes up about 78 percent of the Earth's atmosphere.
Non-point source pollution	See Diffuse source pollution
Nutrient	A substance, element or compound that organisms need to live and grow
Nutrient budget	A calculation comparing nutrients brought onto a farm in fertiliser, feed, and new stock, with nutrients lost in produce, leaching, runoff, and into the atmosphere as gas.
Nutrient management plan	A written plan that documents how the major plant nutrients on a farm will be managed to maximise production or productivity while minimising any adverse effects
Over-the-counter	Over-the-counter (OTC) or off-exchange trading is done directly between two parties
Pathogens	Disease-causing micro-organisms, including many bacteria, protozoa, and viruses.

Phosphorus	A chemical element, symbol P. The most common form of phosphorus is (ortho) phosphate PO_4^{3-}, which is only slightly soluble in water.
Point source (end-of-pipe) pollution	Pollutants from local, stationary sources such as factories or mines, which discharge wastewater through pipes or channels.
Property right	
Riparian	Relating to the banks of a river or wetland; a riparian strip is a buffer zone covered with plants and trees between surrounding land and a waterway.
Run-off	Water moving overland, carrying fine sediment and dissolved pollutants.
Sediment	Material transported by the water. Sediment is generally inorganic material, but can include organic material such as plant fragments, and dead algae.
Stand-off pad	A specially designed area that cows can be moved to during wet periods to prevent them damaging wet or waterlogged soils.
Suspended sediment	Particles of silt, clay, or organic matter floating in water.

9. Appendix 1 - Progressive implementation programmes notified by each regional council

Council	Implementation to be completed no later than:	Progressive implementation programme (on regional council website)
Northland	2026	Programme for implementing the National Policy Statement for Freshwater Management 2014 - Northland Regional Council [PDF, 49 KB] [Northland Regional Council website]
Auckland	2025	Proposed NPSFM progressive implementation programme for public notification [PDF, 91 KB] [Auckland Council website]
Waikato	2027	National Policy Statement for Freshwater Management 2014 (NPSFM) implementation programme [Waikato Regional Council website]
Bay of Plenty	2026	Implementation programme [Bay of Plenty Regional Council website]
Gisborne	2025	Freshwater management progressive implementation programme for the Gisborne District 2016-2025 [PDF, 213KB] [Gisborne District Council website]
Hawke's Bay	2026	National policy statement for freshwater progressive implementation programme for Hawke's Bay [PDF, 4.28 MB] [Hawkes Bay Regional Council website]
Taranaki	2023	Implementation programme for the National Policy Statement for Freshwater Management [PDF, 757 KB] [Taranaki Regional Council website]
Horizons	2027	One Plan Implementation - National Policy Statement On Freshwater Management 2014 [PDF, 196 KB] [Horizons Regional Council website] (Report on Strategy and Policy Committee Agenda, 9 December 2015)
Wellington	2025	NPS implementation timetable [Greater Wellington Regional Council website]
Nelson	2020	Freshwater implementation programme [PDF, 38.2 KB] [Nelson City Council website]
Tasman	2028	Tasman District Council National Policy Statement for Freshwater Management 2014 progressive implementation programme [PDF, 6.8MB] [Tasman District Council website] (Report on pages 13-16 of the Environment and Planning Committee Agenda, 19 November 2015)

Marlborough	2027	Progressive Programme for Giving Effect to Policy A1 – National Policy Statement for Freshwater Management [PDF, 3.39 MB] [Marlborough District Council website] (Report on pages 11-17 of the Planning, Finance and Community Committee Meeting Agenda, 27 July 2017)
West Coast	Completed	West Coast Regional Council reports that the Freshwater NPS 2014 has been implemented in their region.
Canterbury	2027	Canterbury Regional Council progressive implementation programme 2015 [PDF, 14 KB] [Environment Canterbury Regional Council website]
Otago	Completed	Otago Regional Council reports that the Freshwater NPS 2014 has been implemented in their region.
Southland	2027	Environment Southland's Progressive Implementation Programme for Implementing the Policies of the National Policy Statement for Freshwater Management 2014[Environment Southland website]