The condition of rural water and soil in the Waikato region

risks and opportunities

Environment Waikato
REGIONAL COUNCIL

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Purpose of this publication

This publication summarises the current data from Environment Waikato's water and soil monitoring activities and presents trends and possible future scenarios based on these trends. Agriculture is a focus because of its extent, environmental impact, importance to the region and dependence on continued availability of clean water and healthy soil. Rural professionals, therefore, will have a particular interest in this document. Responses from the agricultural sector toward meeting the emerging environmental challenges are included in this publication.

Environment Waikato's responsibilities

Environment Waikato is responsible for implementing parts of the Resource Management Act to meet its purpose of sustainable management. This 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:

- sustaining the potential of natural and physical resources to meet the needs of future generations
- safeguarding the life-supporting capacity of air, water, soil and ecosystems and
- avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Under the Resource Management Act Environment Waikato is also required to:

- control the use of land for the purpose of maintenance and enhancement of the quality of water in water bodies and coastal water
- control discharges of contaminants into or onto land, air or water and discharges of water into water
- not permit an activity if it results in a change in water colour or clarity, water unsuitable for consumption by farm animals or significant adverse effects on aquatic life.

The Waikato Regional Policy Statement sets out Environment Waikato's objectives. These include:

- a net reduction in the destabilisation of the banks of beds and rivers
- a net improvement in water quality across the region
- maintaining the versatility and productive capacity of the region's soil resources
- the range of existing and foreseeable uses of the soil resource not reduced as a result of the contamination of soils.

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The condition of rural water and soil in the Waikato region: risks and opportunities

Executive summary

Primary industry leaders, farmers and growers, researchers, rural professionals and the agencies that support them are taking steps to improve the environmental performance of the agricultural sector. This is in recognition of the increased need for attention to maintaining and enhancing soil and water resources in the Waikato region. The need for clean water and healthy soil underpins profitable farming and healthy ecosystems. The challenge that industry leaders are recognising is that of increasing profitability without compromising environmental quality. This report draws together information from the Waikato region about the condition of water and soil resources, providing a picture that clearly underlines the importance of these industry efforts. Meeting this challenge will ensure a viable and profitable regional economy into the future.

Monitoring shows that important aspects of soil and water quality are deteriorating across the intensively farmed areas of the region. In particular, nutrient concentrations in water are increasing. Sediment and faecal levels remain high in a large number of waterways. There are also indications that soil compaction is a common issue under intensive land use and that some contaminants are building up in soils in parts of the region.

Nutrients from the land – the plant fertilisers nitrogen and phosphorus – are seeping into groundwater, flowing to streams, rivers and lakes, and leading to increased nutrient concentrations in water. Consequently, many of the regions waterways are showing deteriorating trends in water quality. This can ultimately result in lower water clarity, choking weed growth, low oxygen levels and blooms of toxic algae in surface waterways.

Nitrate levels in groundwater do not meet drinking water guidelines in some areas, and further degradation can be expected.

Monitoring of rivers and streams shows that levels of bacteria exceed the Australian and New Zealand guidelines for Fresh and Marine Water Quality 2000 in 75 per cent of sites, and are too high for people to swim safely in 70 per cent of sites.

Trends in turbidity (murkiness mainly due to sediment in water) are showing some improvements over time. Turbidity is low in upland parts of the region (Coromandel, Taupo and upland tributaries of the Waikato River). However, in the lowland parts of the region more than half of the sites in Environment Waikato's sampling programme are classified as unsatisfactory.

Phosphate fertiliser contains cadmium and fluorine. Concentrations of cadmium and fluorine in Waikato's agricultural soils have been gradually increasing. In recent sampling, cadmium concentrations in topsoil were found to exceed a recommended guideline in 11 per cent of properties sampled; fluorine concentrations on some properties may be high enough to require management to prevent a future health risk to animals.

There are indications that soil structure may be deteriorating as a result of stock trampling and machinery use, although seasonal variation can influence the trends shown by monitoring. In the most recent survey only a quarter of our region's dairy farming soils met national soil quality targets.

There are clear links between declining water and soil quality and the intensification of land use in the region. Significant efforts will be needed to reverse the downward trends identified, and to sustain profitable farming without compromising water and soil quality for present and future use. There are already many best management practices identified that, if widely adopted, could reduce the environmental impacts of land use without negatively impacting on the farm business. However, the emerging picture suggests that considerable additional effort will be required by agencies and industry leaders to effectively address the issues.

Introduction

High quality soil and healthy water underpin the Waikato economy. Our farming industries depend on productive soils and clean water. Our drinking water is sourced from rivers and groundwater. People enjoy boating, fishing, collecting seafood and swimming in our lakes, rivers and coastal waters. Visitors are attracted to our appealing environment, and consumers are taking an increasing interest in the farm practices used to produce their food. The well being of both our own society and future generations ultimately depends on keeping our soil and water in good condition.

Plants and animals also rely on these resources. Fish and other aquatic life need clear water to survive in our rivers, streams and lakes. Plants, including those that form the basis of our rural economy, depend on healthy soil.

However, in many parts of our region, the quality of our water and soil is getting worse as a direct result of human activities. What we are doing on the land in the everyday course of earning a living is showing up as changes in the water and soil. If not addressed, the situation could worsen to the point where many of our streams and rivers can no longer be used for stock water, farm dairy use or swimming, and the soil will be unfit for some land uses. Ultimately, because our rivers flow to the sea, our coasts are also affected by what we do on the land.

There is no question that farming is the key to the economic future of the Waikato region – it is the livelihood and vitality of the regional economy. However, increasingly there are signs that for farming itself to survive into future decades, there will need to be some changes. We need to manage our land and water carefully to sustain our economy and our environment.

People living in the Waikato region also have expectations that the environment will be well managed. Water quality is consistently the number one environmental concern for people in the Waikato region (see Figure 1). The proportion of people surveyed who list water quality as their most important issue has risen in recent years, from just over 25 per cent in 1998 to nearly 43 per cent in 2006.

The trends in water and soil quality are reflected nationally, especially where land use is intensifying. A recent analysis of water quality data from around the country found that the most common problem was nutrient levels exceeding guidelines[1]. The dramatic increase in fertiliser use and stocking intensity in recent years has led to a greater focus on nutrient management, which is reflected in this document.

[1] Larned, S. et al. 2005. Nationwide and regional state and trends in river water quality 1996-2002. Ministry for the Environment, Wellington.

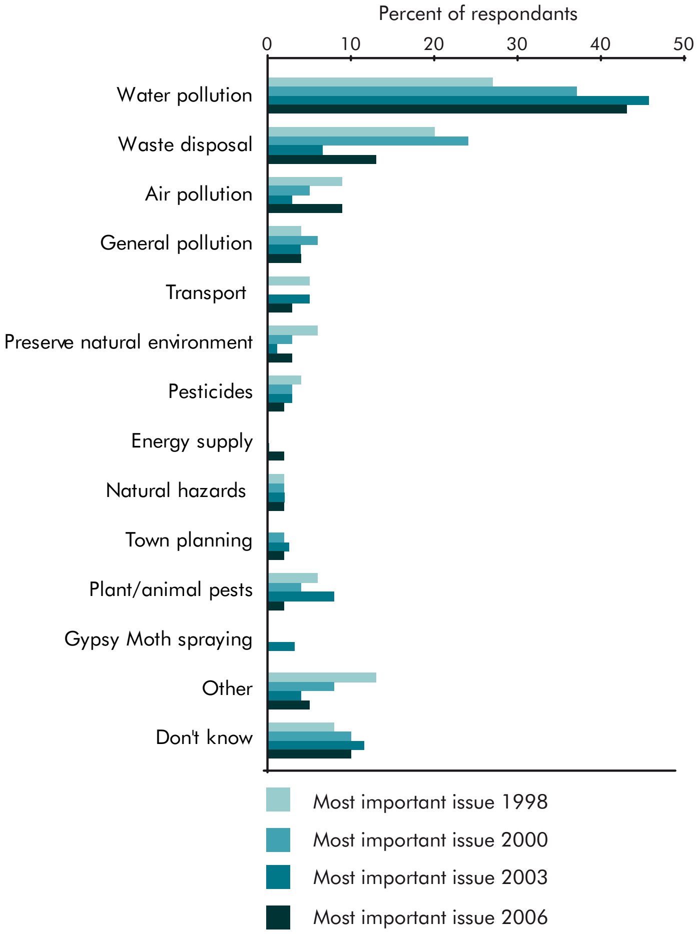

Figure 1 Most important environmental issue for Waikato residents (1998, 2000, 2003 and 2006 survey results)[2]

[2] Environment Waikato Environmental Awareness, Attitudes and Actions Surveys 1998, 2000, 2003 and 2006. Environment Waikato.

What's the state of our water?

Water quality varies across the Waikato region. This is because of differences in land use, contour and underlying rock type. Water quality is best in streams in the less developed, elevated parts of the region with rock or sandy beds. For example, streams in forested Coromandel catchments and those feeding Lake Taupo are clear and unpolluted. However, in the more developed lowland areas of the region, water quality is poorer and streams often fail to meet water quality guidelines.

The risk of groundwater contamination depends on land use, soil type and underground rock and water formations. Shallow groundwater in an area of high intensity land use with a free-draining soil type is most at risk of contamination.

Trends in water quality indicators

Over time several indicators of water quality have been getting worse. Others are showing improvement (see Figure 2). For example, water clarity has improved at many locations. Ammonia levels are also improving and may be the result of increased use of land irrigation to treat dairy shed effluent rather than effluent ponds and discharge to waterways. In particular, levels of nitrogen, phosphorus and conductivity have increased in many rivers across the region (see Figure 3 for examples). This reflects nutrient losses from the overall increase in stock numbers and farming intensity that has occurred in recent years.

Data are being analysed by Environment Waikato for water quality trends from 1987 to 2007. Indications are that both nitrogen and phosphorus concentrations in our rivers are increasing at an average rate of about 2 per cent a year.

Measuring water quality is complex. Many indicators are needed to satisfy the requirements for maintaining or improving water quality for protecting endangered species and human health, and providing water of suitable quality for industry, farming and drinking.

Visual clarity is a measure of how much a water sample scatters/absorbs light. Visual clarity may be affected by turbidity and/or dissolved colour.

E coli are bacteria normally found in the lower intestine of warm blooded animals. Most are harmless, others produce vitamin K, and some are harmful. E coli can live outside the body for short periods and indicate contamination of waterways by animal waste.

Enterococci are bacteria measured as an indicator of human pathogens (disease causing organisms) in water.

Ammonia, a form of nitrogen, is produced from rotting animal and vegetative matter and is used as a measure of this activity in water. High levels will kill fish.

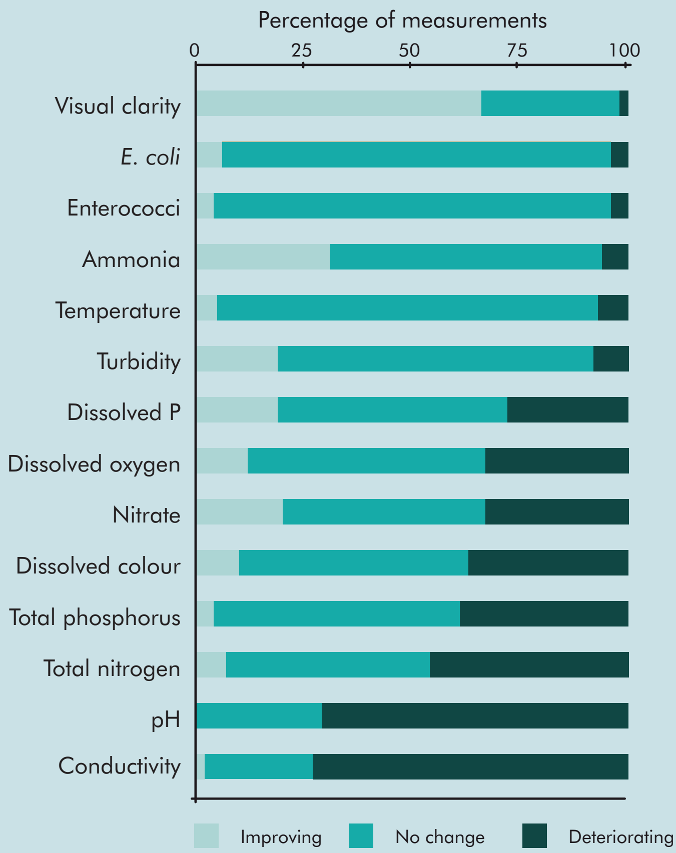

Figure 2 **River water quality trends from rivers and streams (100 sites in the Waikato region, excluding the Waikato River, 1990–2002)[3]**

[3] Vant, B. and Smith P., 2004. Trends in river water quality in the Waikato region 1987-2002. Environment Waikato Technical Report 2004/02. These data are currently being updated.

Temperature of waterways and lakes is a good indicator of biological activity and may be used to predict outbreaks of unwanted organisms. High water temperatures can also kill sensitive aquatic life.

Turbidity is a measure of suspended particles in water and is a key measure of water quality. Particles in water may carry unwanted nutrients (for example phosphate) and prevent sunlight UV radiation killing bacteria.

Dissolved P is a measure of the amount of inorganic phosphorus in a water sample after filtration (<0.45 μm) and is a form readily available to aquatic plants. Exccess P can contribute to undesirable algal growth.

Dissolved oxygen indicates the amount of oxygen available in water. Oxygen is essential for most animal and plant life and low oxygen levels can cause stress in aquatic systems.

Nitrate, a form of nitrogen, is derived from nitrogen fertiliser and also from organice waste. It can enter a freshwater or estuarine system dissolved in surface and ground water. Excess nitrate may result in algal blooms and at high levels can impact on human health.

Dissolved colour is a measure of the amount of organic matter in water. Excessive organic matter will decrease visual water clarity.

Total phosphorus is a measure of available nutrients in the form of phosphorus, much of which may be attached to soil particles accumulated from runoff. Phosphorus may come from fertilisers and natural sources.

Total nitrogen is a measure of available nutrients in the form of nitrogen including proteins from plants and animals, nitrates and ammonia.

pH is a measure of relative acidity or alkalinity. Many aquatic plants and animals have a narrow range of pH at which they thrive.

Conductivity is a measure of the amount of salts in a water sample. Pure water has low conductivity.
A high conductivity can indicate that there are dissolved nutrients.

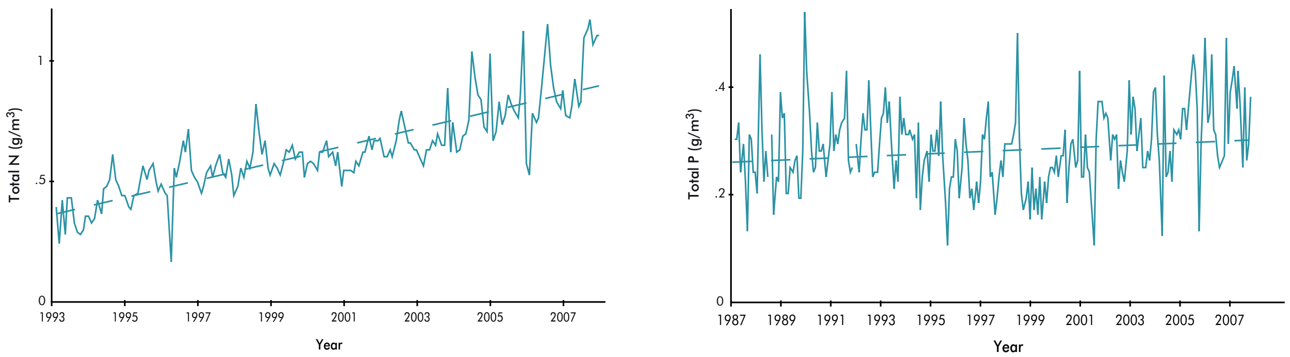

Figure 3 **Examples of increasing nitrate and total phosphorus levels 1987–2007 in the Waipapa stream near Atiamuri. Dashed lines show overall trends in the records[4]**

[4] Vant, B. and Smith P., 2004. Trends in river water quality in the Waikato Region 1987-2002. Environment Waikato Technical Report 2004/02.

Over time the Waikato River has shown improvements in water quality but now some of these improving trends are beginning to worsen. From the 1970s, considerable work has been done to improve the quality of effluent from industrial and urban sources. The 1970s saw major improvements to urban wastewater treatment. The longest water quality record for the Waikato River (at Mercer) shows that this was when river water quality began to improve. The high levels of contaminants evident in the early 1970s fell to levels 10 times lower during the late 1970s and early 1980s.

The 10 year water quality trend for the Waikato River between 1987 and 1996, showed that 22 per cent of measures improved at individual sites and 7 per cent deteriorated. However, for the second 10 year period (1997 to 2006), 9 per cent of water quality measures improved at individual sites but 17 per cent had deteriorated (see Table 1). This deterioration was mainly from increasing nutrient. Amounts of total phosphorus and nitrate in the water are increasing at many sites along the river.

Table 1 **Water quality trends in the Waikato River between 1997 and 2006**[5]

Water quality trends in the Waikato River between 1997 and 2006.

Improving trend; Deteriorating trend; – No change

	Taupo	Ohaaki	Ohakuri	Whakamaru	Waipapa	Narrows	Horotiu	Huntly	Mercer	Tuakau
Temperature	–	Deteriorating	–	–	–	–	–	–	–	–
pH	–	–	–	–	–	–	–	–	–	–
Dissolved oxygen	Improving	Improving	–	–	–	–	–	Improving	–	–
Biochemical oxygen demand	–	–	–	–	–	–	–	–	–	–
Total ammonia	–	Improving	–	–	–	–	Improving	Improving	–	Improving
Total phosphorus	–	–	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Deteriorating	–	Deteriorating	–
Nitrate	–	–	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Deteriorating	Improving
Chlorophyll a	–	–	–	–	–	–	–	–	–	–
Enterococci	–	–	–	Deteriorating	–	–	–	Improving	–	–
Arsenic	Deteriorating	–	–	Deteriorating	Deteriorating	–	–	–	–	–

Based on methods in Environment Waikato Technical Report 2004/02

The largest increases in nitrogen levels have occurred in streams with the most farmland in their catchments. Nutrient levels are lower in streams with forested catchments (see Figure 4) and have changed little in recent years.

[5] Based on methods in Environment Waikato Technical Report 2004/02.

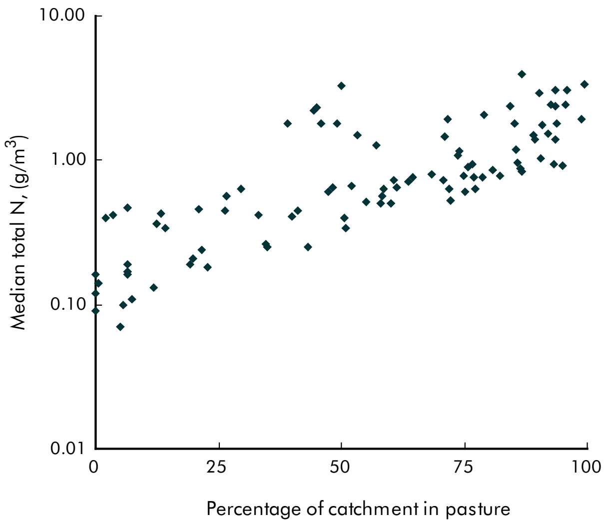

Figure 4 **Median total nitrogen measured during 2000–2004 at 100 Waikato river and stream sites versus proportion of each catchment that is in pasture (note the log scale)[6]**

In the past, pollution control focused on factories, sewage treatment plants and dairy effluent ponds. These are called 'point sources' because the pollution comes from a known single point (such as a pipe to the river from a factory). Through environmental regulation and new technology, major reductions in pollution from these sources have been achieved. For example, the amount of phosphorus entering the Waitoa River from a large point source dropped 95 per cent in less than 10 years as a result of improvements in wastewater treatment. Discharges of nitrogen from point sources to the Waikato River have decreased by 63 per cent over a similar period of time.

However, it is estimated that over the last 10 years, nutrient loads from non-point sources have risen by about the same amount that inputs from point sources have declined[7]. Non-point sources now contribute a greater proportion of contamination to waterways.

What is living in the water?

Another way of telling how healthy streams and rivers are is to survey the number and variety of animals that live in them. Some types of animals (such as the larvae of mayflies, stoneflies and caddisflies) are much more sensitive to poor water quality than other stream dwellers. The presence and abundance of these insects indicates a healthy stream.

Studies of fish living in Waikato streams show that stream health is unsatisfactory at many locations (see Figure 5).

The type of stream life is an indicator of its water quality.

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[6] Vant, B. and Smith P., 2004. Trends in river water quality in the Waikato Region 1987-2002. Environment Waikato Technical Report 2004/02.

[7] Vant and Davies-Colley, Evidence prepared for Environment Court, EcoLogic Foundation and Fish and Game Council vs Waikato Regional Council.

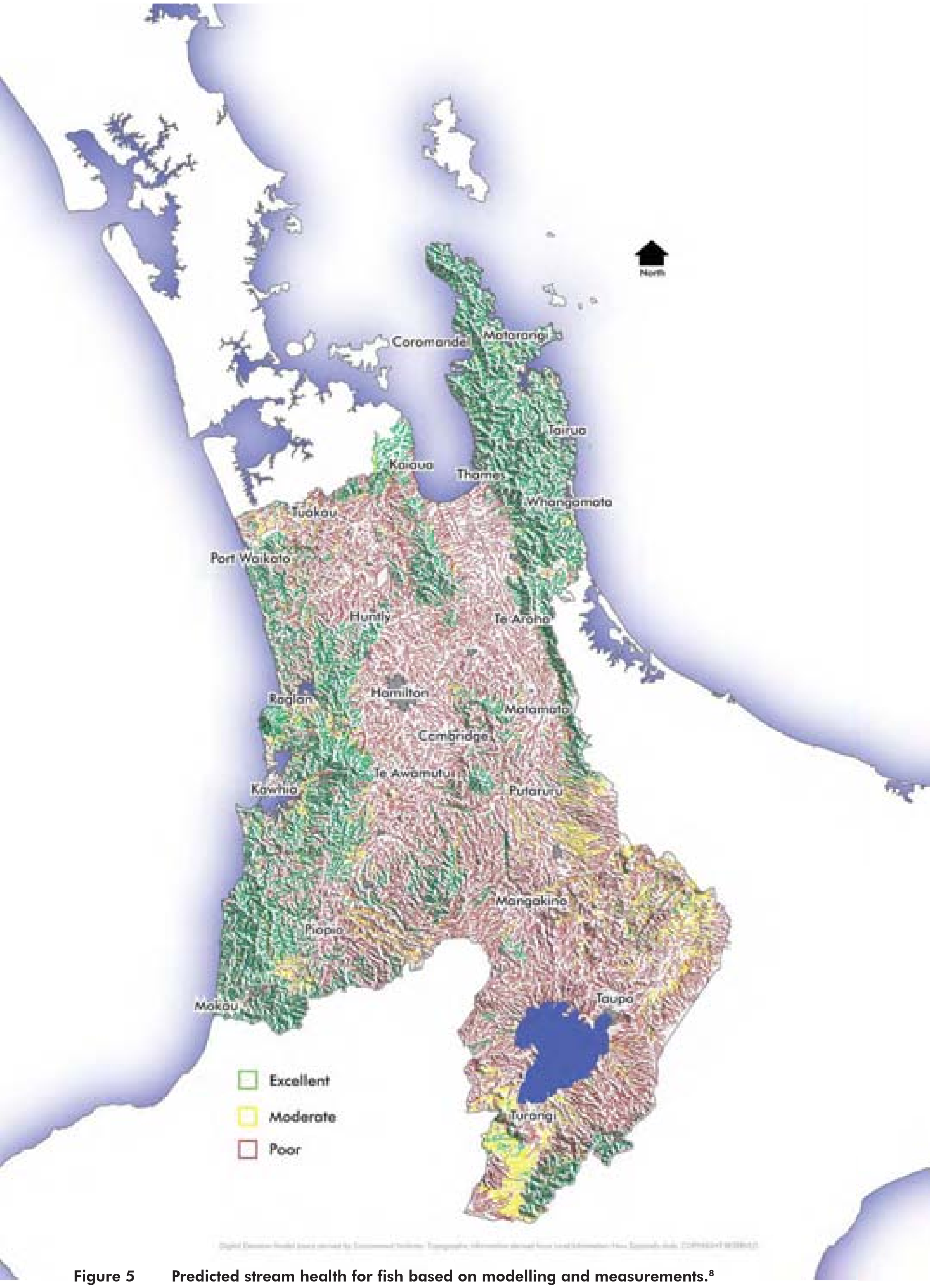


Figure 5 **Predicted stream health for fish based on modelling and measurements.**[8]

[8] Based on Environment Waikato stream monitoring data 2007.

Stream health is much poorer in streams flowing through pasture, compared with those in native forest (see Figure 6).

Good water quality is important for supporting fisheries, including trout. Trout need clear, cool waters with healthy insect populations. Some species of whitebait are also affected by poor water quality. The presence and abundance of native fish and trout are used as a measure of water quality, as are aquatic insects such as the larval stages of mayflies, stoneflies and caddisflies. Snails and worms are more common in degraded streams.

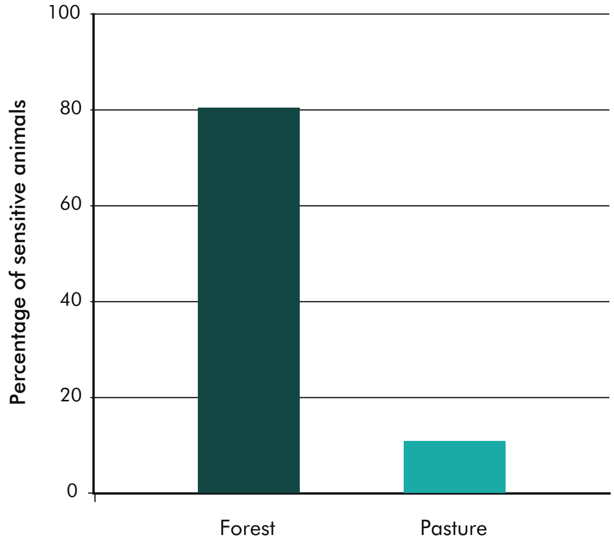


Figure 6 **Percentage of sensitive stream animals in forest streams, compared with pasture streams[9]**

Bacteria in water

Disease-causing micro-organisms such as bacteria which originate from human and animal waste are present in many of our waterways. Human faecal material can enter surface waterways, coastal water and groundwater from malfunctioning sewage treatment plants or septic tanks. Animal faeces can enter waterways when stock are moving through streams, when rain washes dung from the land into water, or from poorly functioning dairy effluent ponds. Bacteria can also come from birds (such as ducks) and animal pests (such as possums).

Why bacteria are a problem

Bacteria from human and animal wastes pose a risk to human health because they include organisms that cause disease in humans. When present in high numbers bacteria can make the water unsafe for contact recreation, food-gathering and the use of water for people or stock to drink.

Bacteria levels in Waikato surface waterways

Testing of the Waikato region's rivers and streams shows that levels of bacteria are too high for safe swimming at nearly 70 per cent of sites sampled. In an even greater proportion of streams sampled (nearly 75 per cent) levels exceed the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (see Figure 7).

Water quality for swimming is worst in lowland tributaries of the Waikato River (see Figure 8). It is also poor in the lower Waipa, and in rivers along the west coast and Hauraki plains. However, on the Waikato River itself, the water is suitable for swimming at nine out of the 10 monitoring sites.

Water quality for swimming is best in streams around Taupo and the upper Waikato River.

[9] Collier, K. and Kelly, J., 2006. Patterns and trends in the ecological condition of Waikato streams based on the monitoring of aquatic invertebrates from 1994 to 2005. Environment Waikato Technical Report 2006/04. Values are means + 1 standard error. 'Forest' sites (25 sites monitored) have catchment entirely in native forest. 'Pasture' sites (29 sites monitored) have >95 per cent of upstream catchment in pasture.

Figure 7 Microbial contamination of waterways[10]

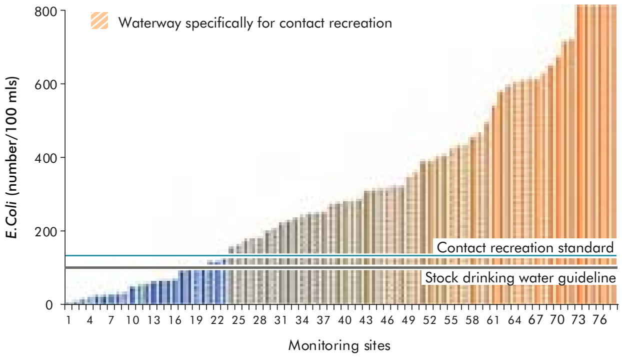
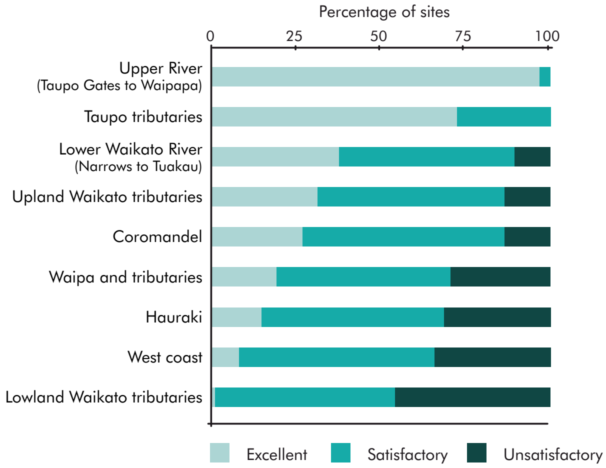


Figure 8 Bacteria levels in Waikato rivers and streams: suitability for swimming[11]



Bacteria in Waikato groundwater

Despite the load of animal faeces deposited on agricultural land, microbial contamination of groundwater in the Waikato region is not widespread. This is because sunlight kills these organisms on the soil surface and long travel times through the soil filters them out before they reach groundwater.

There are exceptions, particularly for wells and bore-heads that are not sufficiently protected from contamination at the surface. Where there is no protective concrete pad around the well, microbes in animal waste can enter the groundwater directly via the bore shaft. Microbial contamination of groundwater can also occur due to poor effluent irrigation practice, or where septic tanks are located in areas of shallow groundwater.

Bacteria in coastal waters

Disease-causing organisms can enter our estuaries and coastal waters from the land. This contamination can occur from leaking septic tanks, improperly functioning sewage treatment plants and toilets on boats. It can also occur when run-off from farms enters the water. This can make beaches unsafe for swimming and shellfish unsuitable for consumption.

Some shellfish farms around the Coromandel Peninsula are closed to harvesting after heavy rain because the rain washes bacteria from the land into the sea.

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[10] Beard, S., 2008. Regional Rivers Water Quality Monitoring Programme: Data Report 2007 Environment Waikato Technical Report 2008/19.

[11] Based on Environment Waikato Indicators for River Water Quality for Contact Recreation.

Sediment in water

Sediment enters waterways when soil and other particles are washed off the land, or when unstable stream banks slump into waterways. The amount of sediment in waterways depends on the soil type and slope, which determine its potential to erode and travel to waterways. Land use also makes a big difference, as land that is protected by mature trees has much lower rates of erosion. Major slips that occur during high rainfall events contribute large 'pulses' of sediment to waterways. However, 'background' erosion from stream banks and run-off from paddocks also contribute significantly to sediment levels in our waterways.

Why sediment is a problem

High levels of sediment result in high turbidity – a measure of the murkiness of water. High turbidity blocks sunlight from penetrating the water and can cause bed-dwelling aquatic plants to die. It also makes it difficult for fish and other animals to see their prey and there is evidence that native fish migrating upstream from the sea will avoid highly turbid streams[12].

The confluence of the Waikato and Waipa (on the right) rivers during flood.

Sediment can be a particular problem in shallow lakes, where wind effects constantly stir up the lake bottom, making the water very murky. This has a compounding effect since it prevents aquatic vegetation from growing on the lake bed and stabilising the sediments.

Sedimentation also affects harbours and estuaries where it can accumulate and accelerate the in-filling of bays. This can smother shellfish and other marine organisms and promote the growth of mangroves, which may impede navigation.

Sediment levels in Waikato waterways

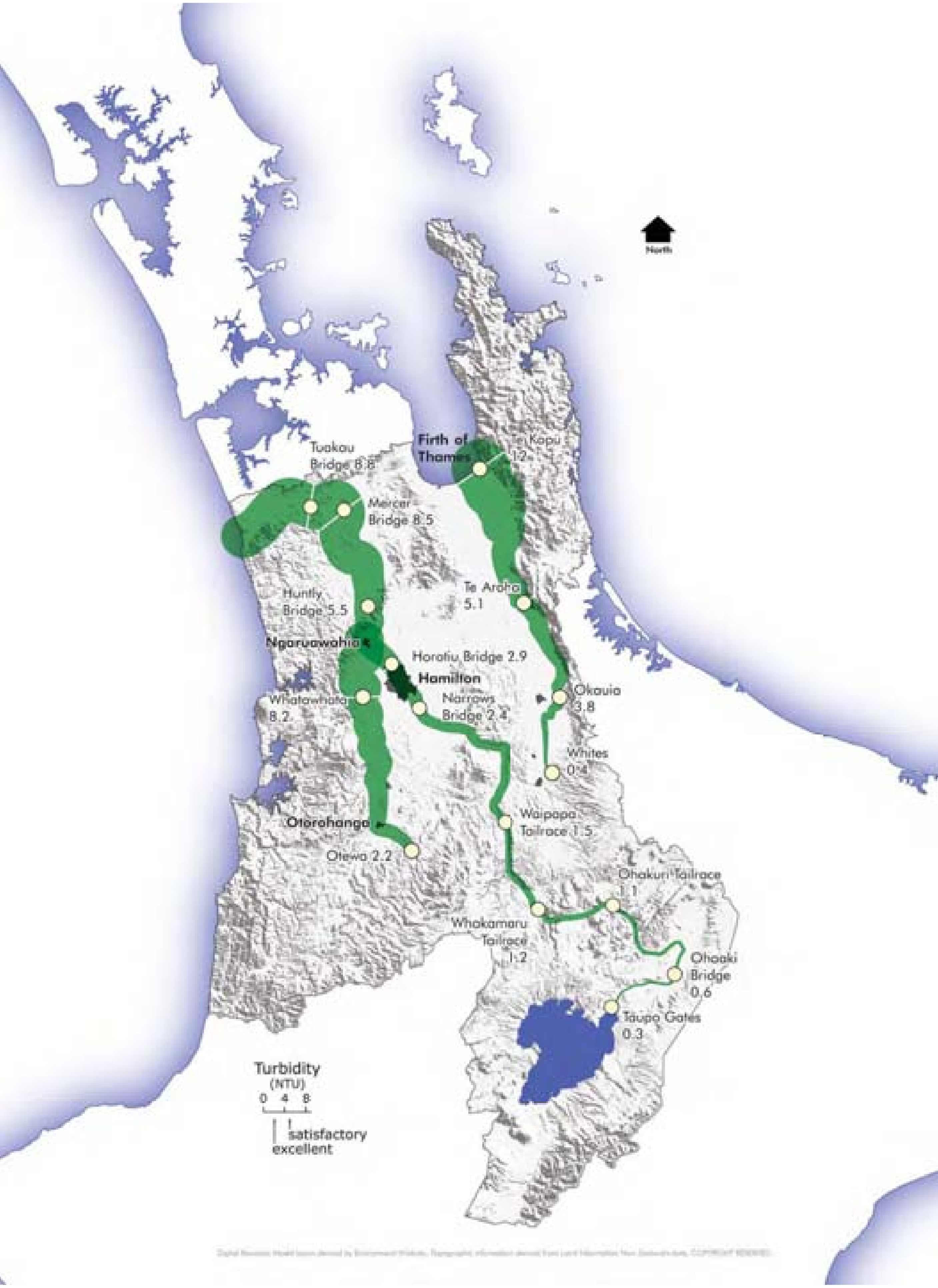
Trends for the region as a whole are showing some improvements over time. During 2000–2004 turbidity (a measure of the murkiness caused mainly by sediment in water) was monitored at monthly intervals at 100 sites in different parts of the region. In upland parts of the region (Coromandel, Taupo and upland tributaries of the Waikato River) on average about 58 per cent of measurements were classified as excellent and only 15 per cent of measurements were classified as unsatisfactory.

However, in the lowland parts of the region (areas below 300 metres above sea level) 56 per cent of measurements were classified as unsatisfactory, and only 15 per cent of measurements were excellent[13].

Figure 9 shows the variation in NTU levels (NTU; a measure of turbidity or cloudiness of a water sample) in Waikato rivers and streams. Drinking water should not be more than 5 NTU, and should ideally be below 1 NTU. NTU levels of less than 25 have little effect on a fishery, while a NTU greater than 80 is unlikely to support a good freshwater fishery.

[12] Rowe, J., et al., 1999. Effects of suspended solids on native fish. NIWA Technical Report. NIWA, Hamilton.
[13] Environment Waikato Indicator for River Water Quality.

Figure 9 Turbidity in Waikato rivers[14]

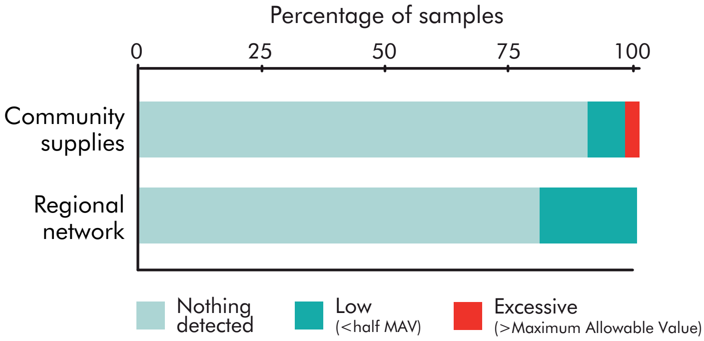


[14] Environment Waikato Regional River Monitoring Programme data.

Pesticides in water

Pesticide levels are low in our surface waters but pesticides are sometimes detected in groundwater. Pesticides are present in a small number of community water supplies at levels above drinking water guidelines (see Figure 10). In most cases, groundwater contamination by pesticides is a result of historic use (such as sheep dips). Groundwater can also be contaminated if concentrated pesticides are mixed near the bore-head or well and spillages occur, allowing pesticides to flow directly into the groundwater.

Figure 10 Pesticide occurrence in monitoring wells in the Waikato region compared with maximum allowable values (MAVs)[15]



Nutrients in water

Nutrients in water originate from animal and human waste, soil, plant material and fertilisers.

The nutrients nitrogen and phosphorus enhance the growth of algae causing water quality to deteriorate in parts of the Waikato region.

The two main problem nutrients (nitrogen and phosphorus) reach water in different ways. Phosphorus travels attached to particles of soil or dung that wash off the land into streams (see Figure 11).

Nitrogen in the form of dissolved nitrate seeps through the soil to groundwater. This process is known as leaching. Once in the groundwater, nitrate can move via underground flow into streams, rivers and lakes (see Figure 12).

Figure 11 Phosphorus movement over the land

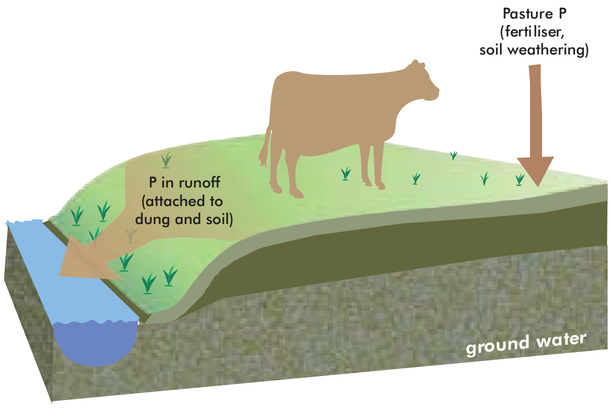
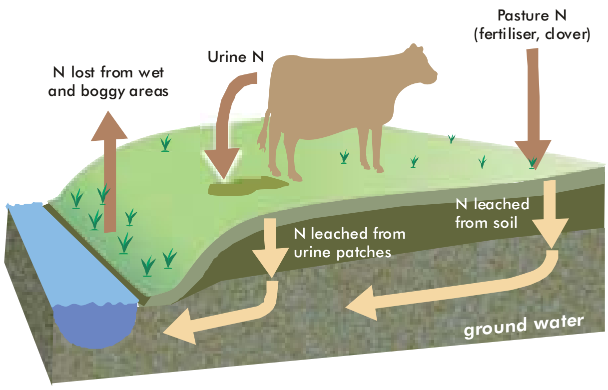


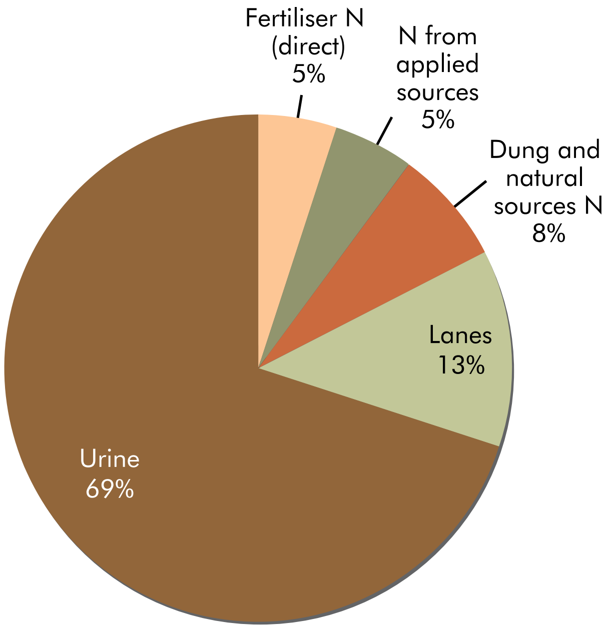
Figure 12 Nitrogen movement through the land



[15] Environment Waikato Indicator for Pesticides in Groundwater.

The majority of nitrogen entering water from grazed farmland comes from stock urine (see Figure 13). The amount of nitrogen in urine patches is far more than plants can take up, so it is prone to leaching out of the soil. By contrast, most of the nitrogen leached from cropping land is released from soil processes, fertiliser and crop residues.

Figure 13 Sources of nitrogen loss on a typical dairy farm[16]



Not all nitrogen that has moved below the soil surface will necessarily enter rivers, lakes or streams. If water is held for long enough in waterlogged soils, seeps or wetlands, bacteria convert the nitrogen into gases, which then escape to the air rather than entering the water. This process protects water quality but in some conditions there may be an impact on the atmosphere, as one of the gaseous forms of nitrogen released (nitrous oxide) is a potent greenhouse gas.

Phosphorus enters waterways in several ways. One is attached to soil or dung washed from the land. Activities that expose bare soil can contribute to phosphorus runoff during wet weather if the dirty runoff reaches waterways. This can result from pugged areas, tracks and raceways or cultivated ground. Phosphorus can also enter waterways from direct application of fertiliser, in effluent, sewage and industrial discharges.

[16] AgResearch data (for a dairy farm producing 850 kg milksolids/ha; using 100 kg fertiliser N; effluent applied to land).

Why nutrients are a problem

Just as they act as a fertiliser on the land, nutrients promote plant growth in surface water, leading to an over-abundance of algae, slimes and water weeds.

Algae growing on rocks.

High levels of algae decrease water clarity, give the water a green appearance and block up water filters. Larger water weeds also block pumps and can choke small waterways. When these water plants die, the dead material is broken down by bacteria, which consume large amounts of oxygen. This results in low oxygen levels in the water that can kill fish and other stream life. Some waterways are particularly sensitive to nutrient enrichment, especially lakes where water spends sufficient time for algae numbers to build up.

An algal bloom on Lake Rotokauri.

The Waikato region is home to some unique lakes, including Lake Taupo with its high water clarity and the peat lakes, a specialised ecosystem. These lakes are threatened by rising levels of nutrients draining into them from their catchments. The particular sensitivity of each lake to higher nutrient inputs varies according to whether existing nutrient levels are limiting algal growth.

In some circumstances, high nutrient levels trigger the growth of toxic blue-green algae that are dangerous to humans and animals. If high numbers of blue-green algae are in the water, it is not safe for people or animals to drink, or even make contact with the water. Major algal blooms have occurred in the Waikato region on several recent occasions. In February 2005, an algal bloom was linked with the deaths of nine cattle on a Waikato farm.

A Waikato farmer has lost nine cattle after they drank from a lake so contaminated by toxic algae that levels were 760 times above animal drinking water standards.

The deaths have prompted public health warnings about algal blooms in several lakes in the region, and a university professor has described Waikato lakes as some of the worst in the country.

NZ Herald, 23 February 2005

Health authorities yesterday warned the public off the river between Orakei Korako, north of Taupo, and Port Waikato after detecting high levels of potentially toxic algae. People have been advised not to have contact with untreated water or drink it even if it's been boiled. Concerns over the quality of the untreated water extend to livestock and animals. Farmers are being advised not to water stock from the river.

People have been advised not to have any contact with the river including swimming and water sports.

Waikato Times, 10 January 2003

Groundwater can also be affected by nutrients. Nitrogen on land can enter groundwater in the form of nitrate, which is soluble and travels with rainwater through the soil. Preventing the loss of nitrogen from the soil is important both for people and for natural ecosystems.

In rural parts of the Waikato region, groundwater supplies about half of people's drinking water. Groundwater is also used to water stock. Groundwater nitrate can build up to levels that pose a threat to people's health. Many streams, lakes and wetlands are also sustained by groundwater. In the Hamilton Basin, up to 85 per cent of the typical flow in small streams comes from groundwater[17]. Nitrate in groundwater can be released into the wider environment as it slowly seeps into streams and rivers, leading to higher nutrient concentrations and algal growth.

Harbours are also affected by what we do on the land.

Streams and rivers ultimately deliver nutrients to the sea, where the ocean ecology can be disrupted by nutrient enrichment. As in freshwater, nutrients in coastal waters can increase the growth of algae. This is more likely in partially enclosed water bodies such as estuaries, which are not as well flushed as the open sea. Blooms of toxic algae can contaminate shellfish, making them unsuitable for gathering.

An over-abundance of algae in seawater decreases visibility for animals that need to be able to see to locate their food, making feeding more difficult. Algae also reduce the amount of light reaching underwater plants by reducing water clarity and by growing on seagrass and seaweeds and intercepting the light they need to survive.

Figure 14 Nitrogen loads (t/y) at various points for the Waikato river and for the combined rivers flowing into the Firth of Thames[19]

Nutrient levels in Waikato surface waterways and lakes

Levels of total nitrogen and phosphorus have increased in many of the region's rivers in the last 10–15 years. Concentrations of total nitrogen in streams across the Waikato region increased by an average of 1.3 per cent every year between 1990 and 2002. Total phosphorus also increased by an average of 1.3 per cent per year in the same period[18].

Total phosphorus and total nitrogen concentrations have tended to increase at a higher rate in streams with more agricultural land in their catchments, and nutrient concentrations are higher in the lower reaches of rivers.

This can be seen in our largest river, the Waikato River (see Figure 14). The water leaving Lake Taupo is so clear that, on average, an object can be seen 14 m away through the lake water. The water quality in the upper section of the river is generally high. However, downstream conditions deteriorate. By the time the water leaves Lake Ohakuri, some 75 km downstream from the outlet of Lake Taupo, it appears green and somewhat murky. Clarity has dropped to 2.5 m. Colour and clarity continue to decline until, in the river's last 50 km, the water is brownish and murky, and the average clarity is less than 1 m. This is due to a combination

[17] Marshall, T., and Petch, R., 1985. A study of groundwater and surface water resources in the Hamilton Basin. Waikato Valley Authority.

[18] Based on data in Vant, B. and Smith P., 2004. Trends in river water quality in the Waikato Region 1987-2002. Environment Waikato Technical Report 2004/02.

[19] Updated from Vant, B., 1999. Sources of the nitrogen and phosphorus in several major rivers in the Waikato Region. Environment Waikato Technical Report 1999/10. These data are currently being updated.

of sediment and algae in the water column. Algal growth is promoted by nutrient inputs along the river and the slowing of water flow in the hydro lakes.

Nutrients levels in lakes

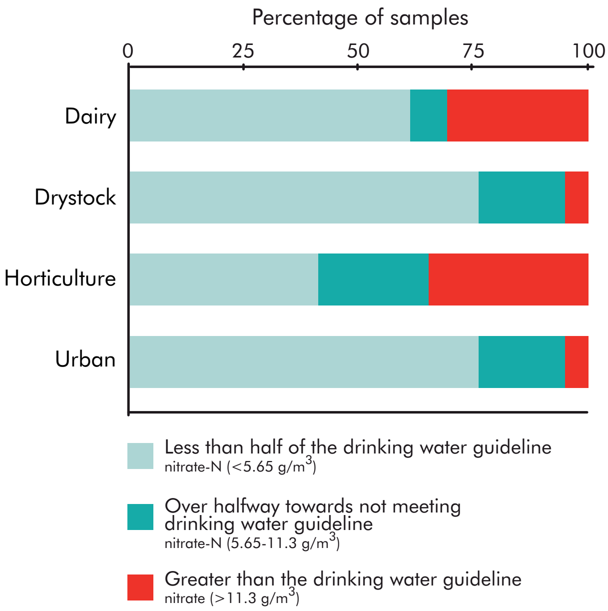
Environment Waikato monitors eight shallow lakes in the region. All these lakes are highly to extremely nutrient enriched and have poor water quality. Nutrient enrichment results from runoff and leaching of contaminants such as effluent, fertiliser and sediment from land use in a lake's catchment. Farmland now surrounds most shallow lakes in the Region. The analysis of the data available until 2001 showed that the water quality of three of the shallow lakes had deteriorated, while that of four others was unchanged. Since then two lakes (Whangape and Waikare) have deteriorated markedly.

Hautapu school bore.

Nutrient levels in Waikato groundwater

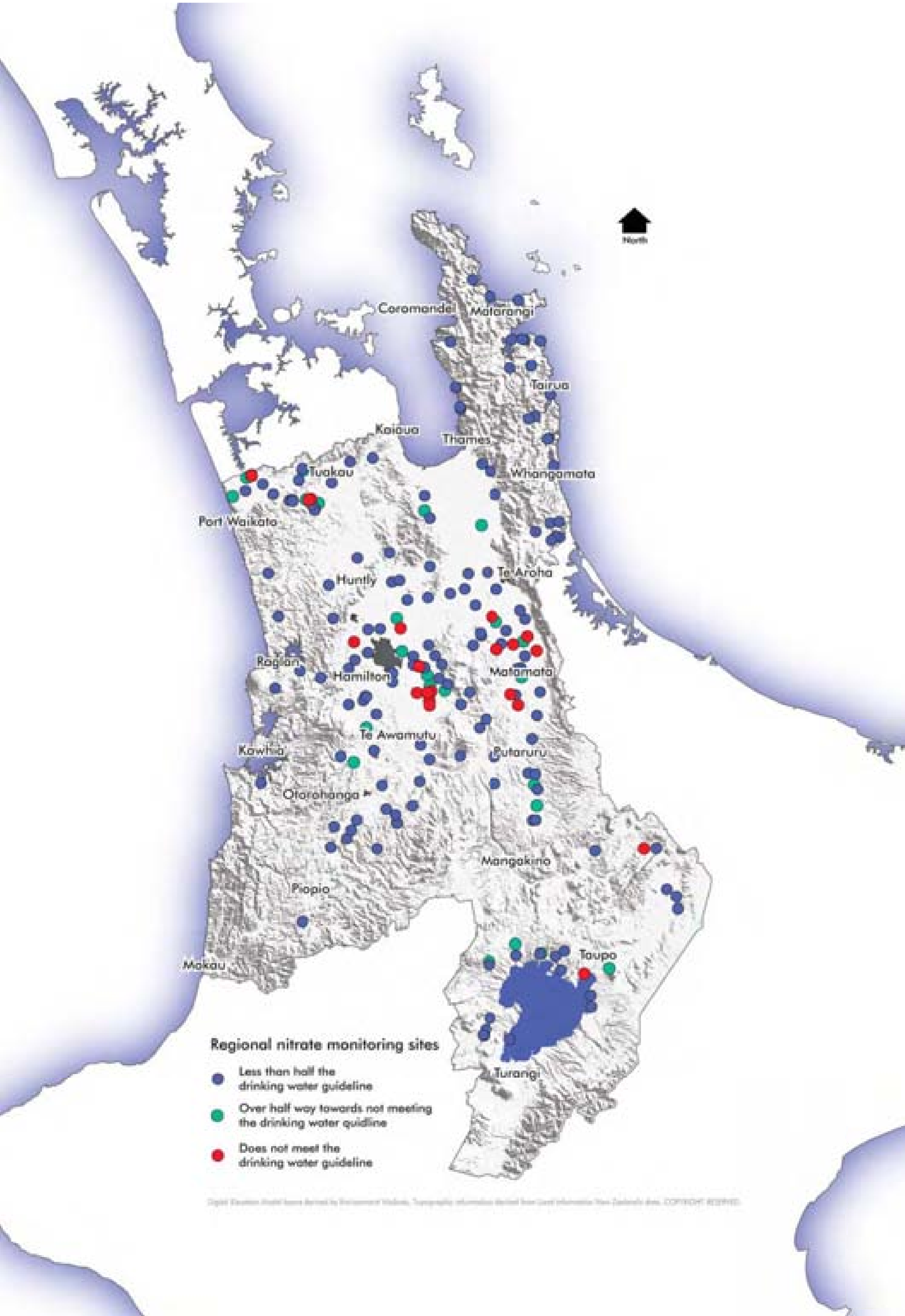
Environment Waikato monitors groundwater at 110 wells around the region. The nitrate concentration in 16 per cent of these general-purpose wells do not meet the drinking water guideline. In two per cent of wells used for community water supplies, levels do not meet drinking water guideline levels. Nitrate concentrations vary with land use (Figure 15) and in different parts of the region (Figure 16). Shallow groundwater under free-draining soils with high intensity land use is most at risk. However, where there are waterlogged areas (such as the wet soils of the northern Hauraki plains), nitrogen is released by soil bacteria back to the atmosphere and is less likely to reach groundwater.

Figure 15 Percentage of Waikato groundwater sites under different land uses that have excessive, elevated or low nitrate levels.[20]



20 Environment Waikato groundwater monitoring data.
21 Environment Waikato groundwater monitoring data.

Figure 16 Nitrate concentrations at groundwater quality monitoring sites[21]



Groundwater nitrate levels most commonly exceed the level considered safe for drinking in the Hamilton-Mangaonua and Pukekohe areas. Up to 40 per cent of shallow groundwater in the Hamilton-Mangaonua area is unsuitable for drinking. The principal land use in the Hamilton-Mangaouna area is intensive dairy farming. In Pukekohe, the main land use is commercial vegetable growing.

Commercial vegetable growing is associated with the highest nitrate concentrations in groundwater. Figure 17 shows how nitrate concentrations in groundwater have increased over 10 years of monitoring in a vegetable growing area near Matamata.

Other intensive land use such as dairy farming can also give rise to elevated nitrate levels (see Figure 18).

Figure 17 Groundwater nitrate concentrations from a bore in a commercial vegetable growing area near Matamata[22]

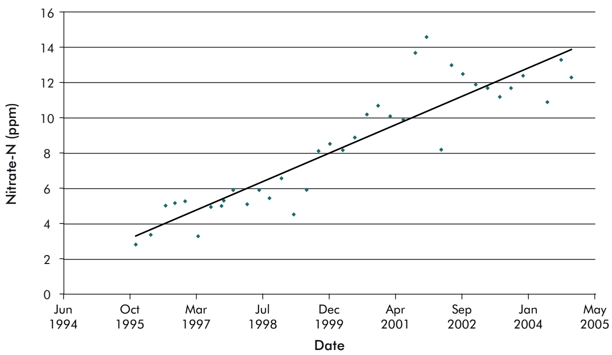
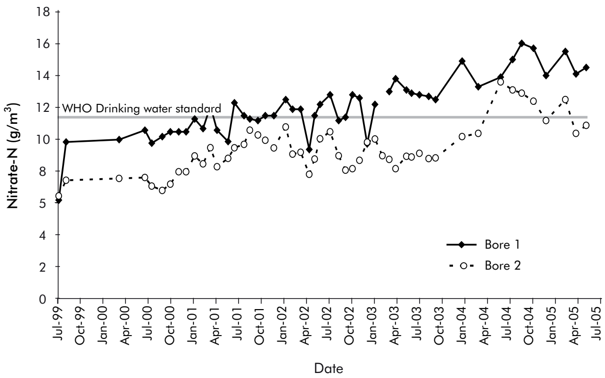


Figure 18 An example of increasing groundwater nitrate levels in two shallow groundwater bores at a Reporoa dairy farm[23]



It can take many years for the groundwater in which nitrogen is dissolved to travel through the land before emerging in streams, rivers and lakes. In areas where groundwater moves slowly, the nutrient levels we see in surface water today reflect the activities that took place decades ago. More nitrate has entered groundwater as land use has intensified in recent years, but this has yet to reach our rivers, streams and lakes and may not be seen for several decades. This means we can expect to see water quality worsen in some of our rivers and lakes in the future, even if we make changes today.

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22 Environment Waikato groundwater monitoring data.
23 Environment Waikato groundwater monitoring data.

It can take years for groundwater to reach streams[24]

Water in the streams around Lake Taupo fell as rain on the surrounding hills between 30 and 80 years ago, on average. Since then, it has been gradually seeping through the ground.

Farming started increasing around Lake Taupo in the 1950s. In the process of clearing the land, large quantities of nitrogen were released. The effects of this are only now beginning to be seen in increased nitrate levels in streams around the lake.

Sampling found that in some streams around Lake Taupo, water has moved very slowly through the ground and into streams. In these streams, only 30-50 per cent of the water is young enough to show the effects of increased pasture development in the last 45 years. The remaining water entering these streams is older, and fell on the catchment before widespread development of farming. Nitrate levels in this water are low.

Other streams have a higher proportion of younger groundwater (70-100 per cent of the stream water is less than 45 years old). Higher nitrate levels are found in this younger groundwater, as a result of recent changes in farming. In these streams, nitrate levels have increased.

Nitrate levels in streams around Lake Taupo are predicted to rise in future as the contribution of water showing the effects of more intensive farming grows. There is a range in predicted increases, from 30-40 per cent above current levels. While the exact amount of increase to come is not certain, scientists agree that the amount of nutrients entering the streams – and therefore the lake – will rise.

Nutrient levels in coastal water

In general, the region's estuaries and harbours do not show excessive nutrient levels.

Blooms of toxic algae do occur in the sea around New Zealand. These are thought to be, at least in part, a natural phenomenon in the oceans[25]. However, algal blooms could increase in future in enclosed bays and estuaries of the Waikato region as a result of increased inputs of nitrogen from the land. A lack of nitrogen limits the growth of algae in the sea. This is unlike many of the region's freshwater bodies that are phosphorus-limited (due to already high nitrogen levels).

Nitrogen inputs to the sea can be high:

- the equivalent of 97 truckloads of urea fertiliser enters the sea at Port Waikato every week
- the equivalent of 32 truckloads of urea fertiliser enters the Firth of Thames every week[26].

NIWA has modelled the effects of increasing nitrogen inputs to the Firth of Thames. 50-70 per cent of the mineral nitrogen in the Firth is from rivers. This modelling also shows that algal blooms are very likely to occur around the mouth of the Waihou River and extend into the Firth of Thames by 5-10 km if there is a five-fold increase in nitrogen reaching the Firth[27]. While this may seem a large rise in nitrogen, it should be remembered that there is a lag in groundwater nitrate reaching rivers and then the sea. Therefore, current levels of nitrogen reaching the sea do not yet reflect the large increases in nitrogen use of recent years.

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[24] Morgenstern, U., 2007. Lake Taupo Streams: Water Age Distribution, Fraction of Land Use Impacted Water, and Future Nitrogen Load. Environment Waikato Technical Report 2007/26.

[25] Chang H. and Mullan B., 2003. Occurrence of major harmful algal blooms in New Zealand: is there a link with climate variations? The Climate Update, No. 53; Hauraki Gulf Forum 2005, The Hauraki Gulf State of the Environment Report.

[26] Based on Vant, B., 1999. Sources of the nitrogen and phosphorus in several major rivers in the Waikato Region. Environment Waikato Technical Report 1999/10.

[27] Broekhuizen, N. and Zeldis, J., 2006. Forecasts of possible phytoplankton responses to elevated riverine nitrogen delivery into the southern Firth of Thames. Environment Waikato Technical Report 2006/11.

What's the state of our soil?

The Waikato region has a wide range of soils, which include some of the most productive soils in New Zealand. However even high quality soils can be degraded through some land use practices. Compaction (the loss of spaces within the soil) and excessive fertility are the main soil quality issues in the intensively used areas of the Waikato region. Soil loss through erosion is also of concern, especially in hill country. The build-up of contaminants in soils has the potential to be a major issue in the future if current trends continue. Impacts of increasing stock density and continued subdivision of productive rural land are also important issues.

National soil quality targets have been developed by the Ministry for the Environment[28]. Of the 133 sites sampled in the Waikato region, only 34 per cent fully meet the national targets, with compaction and excessive soil fertility being the most common problems. This figure varies between different land uses (see Table 2).

Table 2 Percentage of Waikato sampling sites under different land uses meeting all national soil quality targets[29]

Land use	Percentage of Waikato sites sampled that met all national soil quality targets
Dairy	27
Sheep and beef	36
Plantation forest	44
Horticulture and cropping	54

Compaction

Excessive stocking pressure leads to trampling or 'pugging' of soil, breaking up the soil structure and compressing spaces in the soil (compaction). A similar effect can occur as a result of excessive machinery traffic or cultivation of cropping soils. Damage to the soil is worse when pressure occurs during wet conditions, as this can cause major changes to the soil surface and to the structure below the ground[30].

An uncompacted topsoil on the left contrasts with the compacted soil on the right.

When a soil is compacted, water is no longer able to easily pass through it. Instead it ponds on the soil surface or runs off into waterways. This run-off can contaminate streams and lakes with faeces, nutrients and sediment.

Pugging and compaction also impact on farm income. Pasture growth is reduced immediately as plants are damaged and the area of bare ground increases[31]. The effects continue into future seasons, as the lack of air space in a compacted soil depresses productivity, leading to lower fertiliser responses and lost production.

Sampling at 133 sites in the Waikato region found that compaction of dairy pastures in 2004 was worse than when previously surveyed in 1998/99[32]. However, seasonal variation can have a marked influence on the incidence and severity of pugging and compaction. Of the dairy farms surveyed in 2003 to 2007, 55 per cent

[28] Sparling, G. et al., 2003. Provisional targets for soil quality indicators in New Zealand. Landcare Research.
[29] Sparling G., 2005, Environmental indicators for land: overall soil quality in the Waikato Region 1998-2004. Environment Waikato Technical Report 2005/47.
[30] AgResearch, 2003. Managing treading damage on dairy and beef farms in New Zealand.
[31] AgResearch, 2003. Managing treading damage on dairy and beef farms in New Zealand.
[32] Sparling G., 2005, Environmental indicators for land: overall soil quality in the Waikato Region 1998-2004. Environment Waikato Technical Report 2005/47.

did not meet soil structure targets due to compaction. A third of sheep and beef farms and 10 per cent of horticultural properties also showed evidence of compaction.

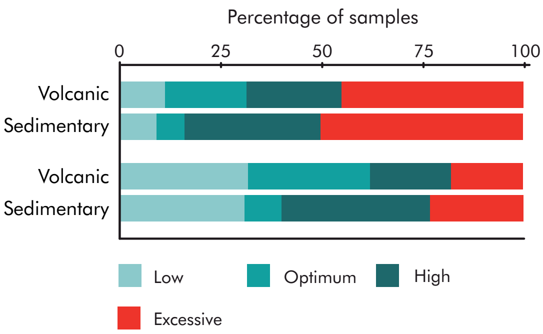
Excessive soil fertility

When more fertiliser is added than plants can take up, the excess can leach into groundwater, or wash off the land when it rains, causing waterway pollution.

Soil samples from Waikato farms show that in some cases more phosphate fertiliser is being added than plants can absorb. On dairy farms, many soil samples (44 to 50 per cent) from volcanic and sedimentary soils show excessive phosphorus fertility. This increased markedly between 1996 and 2001 (see Figure 19). About 10 per cent of samples from sheep/beef farms have excess phosphorus fertility.

Environment Waikato's own soil quality monitoring shows that about one quarter of pastoral soils have excessive levels of phosphorus. Sampling of horticulture and cropping soils shows that about a third of samples have excessive phosphorus fertility[33].

Figure 19 Soil Olsen P levels for dairy farms[34]



Excessive soil fertility comes at a cost to farmers.

- Close to $25 million worth of nitrogen is lost from soil on Waikato farms every year[35]. This equates to $2912 per year for an average dairy farm and $3328 for a sheep and beef farm. While N loss per hectare is lower on sheep and beef farms, total loss is similar due to the much larger size of these farms.
- Nearly $3 million worth of phosphorus is lost in run-off from Waikato farms every year. This equates to $160 for each dairy farm and $954 for a sheep and beef farm.
- Nutrient budgets could save dairy farmers $6000 in fertiliser costs, on average, every year, without decreasing productivity[36]. Some farmers have achieved much greater savings from nutrient budgeting, for example $15,000 or even as high as $100,000[37].

[33] Sparling G., 2005, Environmental indicators for land: overall soil quality in the Waikato Region 1998-2004. Environment Waikato Technical Report 2005/47.
[34] Wheeler, D.M., 2004. Trends in Olsen P test over time for the Waikato region: Waikato Regional Council. Environment Waikato Technical Report TR 2004/09.
[35] Environment Waikato, 2004. Economic value of farm nutrient losses and nutrient excess for dairy and sheep and beef farms.
[36] Edmeades, D., 2002. Nutrient budgeting: how, when, where and why? Report for Environment Waikato.
[37] D. Edmeades, pers. comm.

Soil loss

Bare or cultivated ground is at risk of topsoil erosion. A recent survey[38] using aerial photography indicated that region wide, bare soil is around 1.4 per cent of total land area, of which:

- soil freshly disturbed by land use is around 1 per cent of the region's area – mostly either topsoil exposure by livestock grazing in pasture, or disturbance by farm and forest tracks
- soil freshly disturbed by natural processes is around 0.4 per cent of the region's area.

When soil is lost from productive areas, it takes valuable nutrients with it. The value of nutrients in Pukekohe vegetable growing topsoils is estimated at $8000-$26,000 per hectare. Between 7 and 30 tonnes of topsoil per hectare are lost every year through erosion. This represents losses of topsoil nutrients to the value of $35-$570 per hectare per year[39].

Soil erosion also disrupts farm and district infrastructure and increases the costs of maintenance activity, such as clearing culverts and drains, and re-fencing eroded areas. Franklin District Council estimates that damage to infrastructure (such as blocked drains) caused by soil loss from cultivated land costs the district between $500,000 and $1 million every year to clean-up. Costs to Environment Waikato from the need to frequently clean soil from drains are estimated at about $100,000 every year.

Soil contamination

Pesticides, animal remedies and residues from some fertilisers can contaminate soil. These can be present as a result of historic and/or current activities.

Substances that do not naturally break down, or do so only slowly, are most likely to be detected in the soil. Although these chemicals may be applied in small amounts, they will gradually build up in the soil and can reach levels that are dangerous to the environment, or to people's health. In the long-term, it is possible for some contaminants to rise to levels that are so high that soil can no longer be used for growing crops, or animals, or for people to live on.

DDT

In the past, highly persistent pesticides such as DDT were used to control plant and animal pests. DDT was widely used on New Zealand pastoral land for the control of grass grub from the 1950s until the 1970s. DDT can no longer be used but is still present in soil in many parts of the Waikato region. It takes about 30 years for half the DDT in soil to break down and up to four times longer for it all to break down.

DDT in soil is a particular problem for the dairy industry because it is taken in by cows from the soil and then passes into milk.

The New Zealand dairy industry will not accept milk from properties with high DDT levels. Prospective dairy farmers are required to prove that DDT levels in the soil of proposed dairy conversion properties are low enough to prevent DDT entering milk.

Although DDT has not been widely used for 30 years, analysis of Waikato farms in 2002 showed that levels in soil were too high for dairy farming in over 40 per cent of samples submitted by landowners wishing to convert land to dairy farms[40].

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[38] Hicks, D., 2003. Soil intactness assessment of the Waikato Region. Environment Waikato Technical Report 2003/14.
[39] Edmeades Consultants Ltd, 2002. The content and value of nutrients in the topsoils of Franklin District. Environment Waikato Internal Series IS02/06.
[40] Hill Laboratories data, 2002. Note, in May 2006 the Fonterra standard for DDT residue was raised from 0.2 to 0.7 mg/kg soil. Land that was previously unsuitable for dairy conversion may now comply with the new standard.

Cadmium and other contaminants in fertilisers

Cadmium is present in phosphate fertilisers. It occurs naturally in the rock deposits from which these fertilisers are made. Cadmium does not break down, so levels in the soil increase over time as more phosphate fertiliser is applied.

Cadmium can be harmful to human health and can enter the food chain by being taken up from the soil in crops and by grazing animals.[41]

Vegetable growing can require high fertiliser inputs.

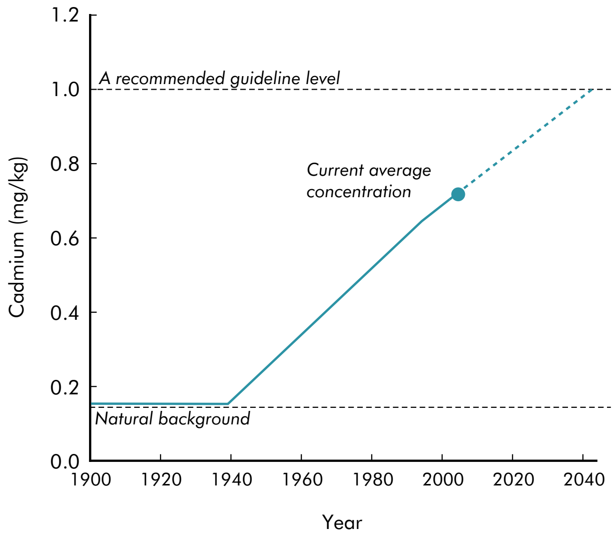
Since the use of phosphate fertilisers became widespread in the 1940s, concentrations of cadmium in Waikato's agricultural soils have been gradually increasing (see Figure 20). Environment Waikato's recent sampling data, indicates that average concentrations of cadmium in Waikato agricultural topsoils are now about five times higher than their natural levels. Eleven per cent of over 200 Waikato properties sampled exceeded a recommended cadmium guideline level of 1 mg/kg[42, 43].

In the Waikato region, phosphate fertilisers are currently applied to approximately 53 per cent of Waikato's total land area (this includes sheep, beef and dairy farmland, arable cropping and horticultural land). Cadmium accumulation rates are highest on dairy land and under some horticultural land uses, like potato growing. Environment Waikato's monitoring shows that at current loading rates the average cadmium concentration in Waikato dairy soils would be at the guideline level in about 15 years time.

While not posing an immediate health threat, cadmium needs to be actively monitored and managed, with a strategy developed to mitigate and manage the risks.

Fluorine is also present in phosphate fertilisers. Soil monitoring data[44] suggests that fluorine build-up is an emerging problem in the Waikato region's agricultural soils. The average concentration of fluorine in Waikato soils is now about twice the natural level. Recent research suggests that fluorine on some properties is approaching levels where grazing and fertiliser management may be required to prevent a future risk to animal health.

Figure 20 Cadmium accumulation in Waikato agricultural soils[45]



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[41] U.S. Department of Health and Human Services, 2005. Report on Carcinogens, Eleventh Edition. Public Health Service, National Toxicology Program.

[42] New Zealand Water and Wastes Association (NZWWA), 2003. Guidelines for the Safe Application of Biosolids to Land in New Zealand.

[43] UK DEFRA and EA (Department of Environment, Food and Rural Affairs and Environment Agency), 2002. Assessment of Risks to Human Health from Land Contamination: An overview of the development of soil guideline values and related research. Report CLR 7. Bristol, UK: Environment Agency. Selected in accordance with Ministry for the Environment, 2003. Contaminated Land Management Guidelines No.2. Hierarchy and Application in New Zealand of Environmental Guideline Values.

[44] Environment Waikato monitoring data.

[45] Environment Waikato monitoring data.

Zinc

Zinc is another contaminant that can accumulate in soil. Zinc is far less toxic to people than cadmium. However, it can have environmental effects at lower levels than those that pose a risk to human health. Zinc passes into water easily, where it builds up in the sediments of rivers, lakes and estuaries and can have a toxic effect on sediment-dwelling creatures and aquatic plants.

Zinc is an ingredient in facial eczema remedies, which are widely used in cattle and sheep farming. It is fed to sheep and cattle, either in water, with feed, or as a drench. It can also be directly sprayed onto pasture. High levels of zinc need to be fed to animals to prevent facial eczema, and much of the zinc is excreted by the animal. It then builds up in the soil.

Currently, we do not know whether zinc from animal remedies is having an effect on the environment in the Waikato region. However, there are indications that zinc is building up in Waikato lake sediments.

Zinc is a contaminant in urban stormwater, and is one of the major sources of sediment contamination in urban waterways. Zinc is also present in fungicides that are used on some horticultural crops. When these sprays break down in the soil, the zinc remains. Zinc is also commonly used as a feed additive in pig farming. Pig manure can therefore be another source of zinc.

Copper

Copper is widely used as a fungicide on specific horticultural crops. Most of the copper applied accumulates in the surface soil. Copper is also used as a fungicide in forestry and as a feed additive in pig farming. Pig manure usually contains very high concentrations of copper. Levels of copper can build up very quickly in soils used for some crops. The amounts of fungicide used on avocados, for example, mean that soil levels of copper can exceed environment protection guidelines after just three years of application[46].

Rural subdivision

For the ten years between 1991 and 2001 3,196 hectares of rural land was subdivided into properties less than four hectares. For the five year period between 2001 and 2006 3,936 hectares were subdivided. In the following five years, 2001 to 2006, 3,936 hectares were subdivided. Thirty to 40 per cent of subdivision occurred on land with the highest productive capabilities (LUC Classes I and II). Overall, three-quarters of the land affected by subdivision had a 'high productive capability for pastoral use' (LUC Classes I to IV).

Properties less than four hectares are overall likely to have decreased production compared with pre-subdivision production levels. This subdivided land has effectively been removed from large scale agricultural production, forcing this use onto land with a lesser productive capability. Some properties below four hectares may be used for intensive agricultural and horticultural uses that generally require much more fertiliser, water and energy than large-scale agricultural enterprises.

Rural subdivision is predominantly occurring in peri-urban areas. This could be an issue for the future if the most versatile land, suited to a wide range of crops, is subdivided to the extent that intensive food production can only occur on less suitable soils. This would have greater environmental impacts and would limit the range of crops that could otherwise have been grown.

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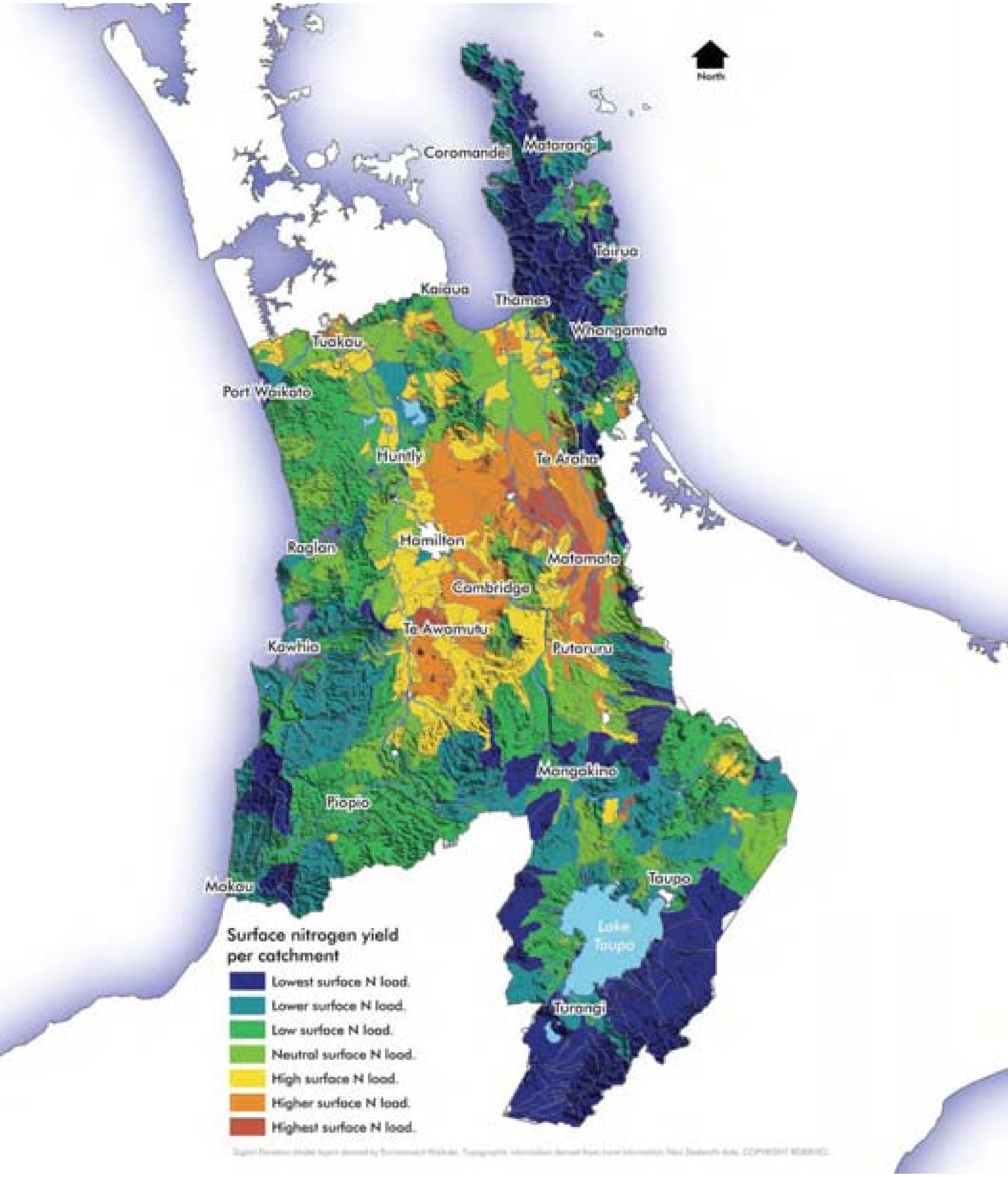
[46] Biosolids Guidelines, Cu 100 mg/kg: protection against phytotoxicity.

Links to land type and land use

Indicators of soil and water quality reflect both the different land types and the different land uses across the region. These differences can be seen in Figures 21 and 22. Larger amounts of nitrogen are lost to waterways from the central Waikato basin and the Matamata/Tirau area than from other parts of the region. However, these areas generate only modest amounts of sediment. Conversely, the western part of the region generates more sediment, but lesser quantities of nitrogen.

Figure 21 Surface nitrogen load in catchments[47]



[47] Brown, L. et al., 2002. Modelling surface water nitrogen. Proceedings of the New Zealand Soil Science Society Conference, Wellington.

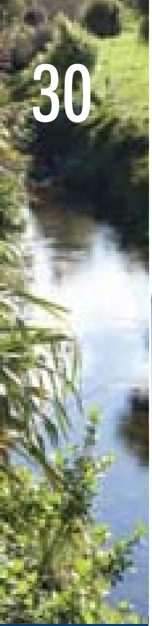
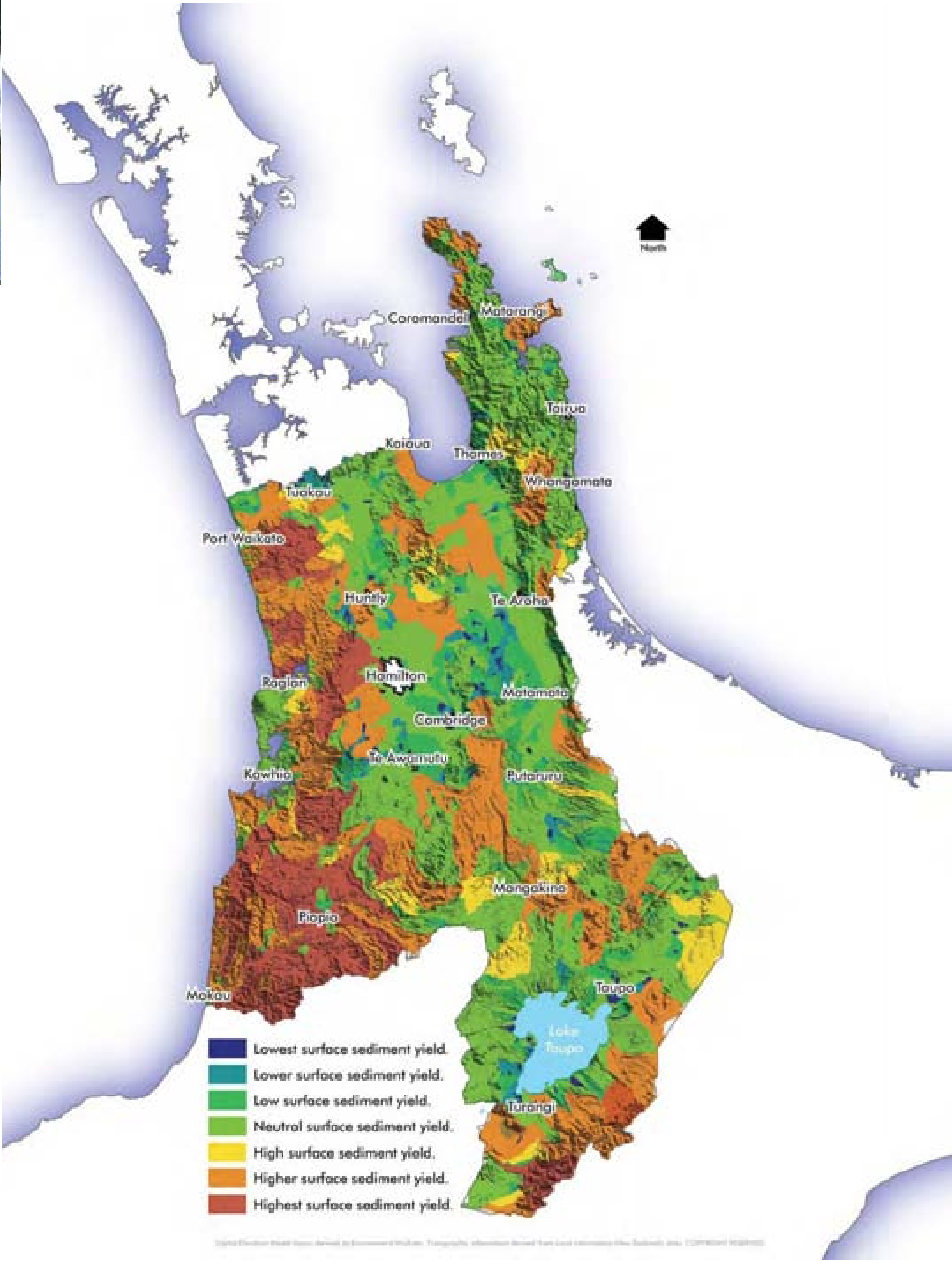


Figure 22 Sediment yield from catchments[48]



[48] Sediment yield data derived by Environment Waikato using the NIWA Suspended Sediment Yield Model. See Hicks, D. et al., 2003. Sediment yield estimates: a GIS tool. Water and Atmosphere 11(4): 26-27.

Differences in land use and land type mean that different management approaches are needed to protect water quality in different parts of the region. In the western part of the region, for example, the priority may be to decrease sediment inputs to streams. By contrast, in the central part of the region a greater emphasis may be placed on nitrogen loss.

However, the appropriate management focus also depends on the sensitivity of receiving waters to various contaminants. In shallow groundwater, nitrate may be of concern for health reasons. In some surface waterways and in the sea, nitrogen is the most important nutrient limiting algal growth and leaching may be the focal issue. In other surface waterways, phosphorus limits algal growth, and run-off or erosion control may need to be targeted in order to limit phosphorus inputs. In many waterways, nitrogen and phosphorus are 'in balance' so that increases in either or both nutrients can have an effect. For water bodies with high recreational or food-gathering use, faecal contamination and sediment may be the highest priorities. In waterways where nutrient enrichment, sediment and faecal matter are all of concern (such as some enclosed estuaries), a broad management focus will be required.

In areas where water quality is high (for example, Lake Taupo) protection is particularly important. In other locations the community may accept lower water quality. In some of our productive landscapes where water quality is poor, it is not always realistic to expect substantial improvements, so a more appropriate focus may be to prevent further deterioration.

Nutrients and land use

The rate of nitrate loss from soil varies for different land uses. Compared with native forest, on average, sheep and beef farms leach about five times more nitrate per hectare, dairy farms 12 times more, and vegetable growing land 100 times more (see Figure 23).

While horticulture loses nutrients at a high rate per hectare, its total contribution to nutrients in Waikato waterways is not large, because it presently covers only a small area of land (see Figure 24).

Figure 23 Loss of nitrogen from different land uses [49]

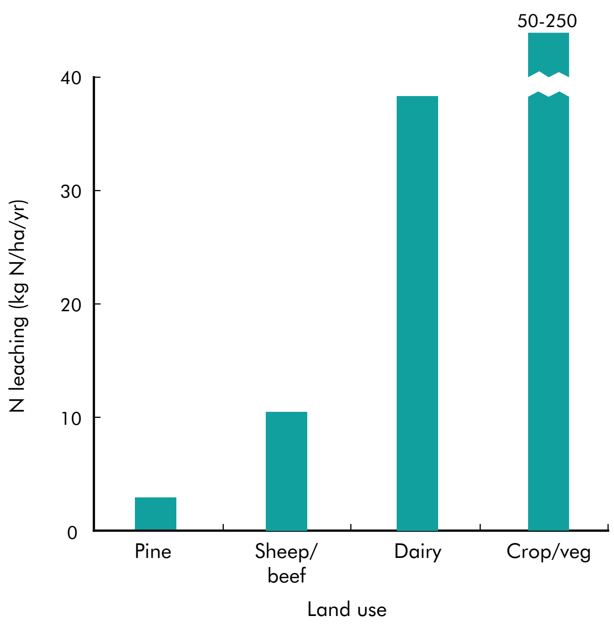
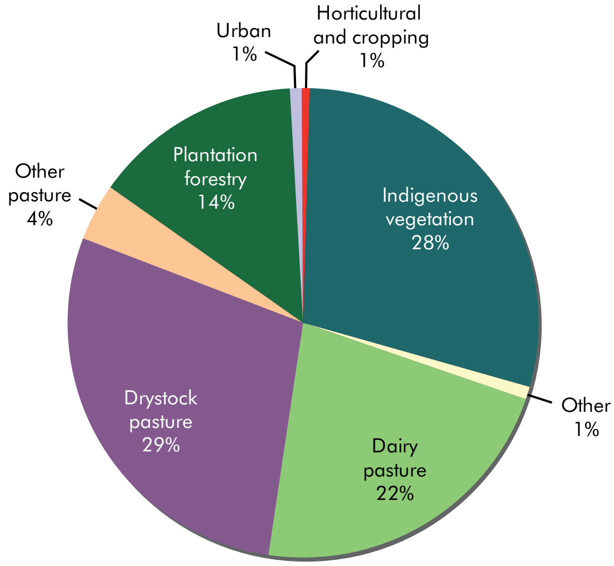


Figure 24 Area under different land uses in the Waikato region[50]



[49] AgResearch data.
[50] Derived from Ministry for the Environment, 2002. Landcover Database II; AgriQuality Ltd, AgriBaseTM database snapshot on 1st July 2004; Land Information NZ Landonline data and valuation data sourced from Territorial Authorities Valuation Roll.

While only 22 per cent of the Waikato region is used for dairy farming, the high rate of N loss under dairy farmland means that 68 per cent of the total nitrogen losses in the region come from dairy farming (see Figure 25).

Point sources such as factories now only contribute a small amount of total nitrogen to Waikato waterways (see Figures 25 and 26).

Figure 25 **Sources of nitrogen entering streams in the Waikato region**[51]

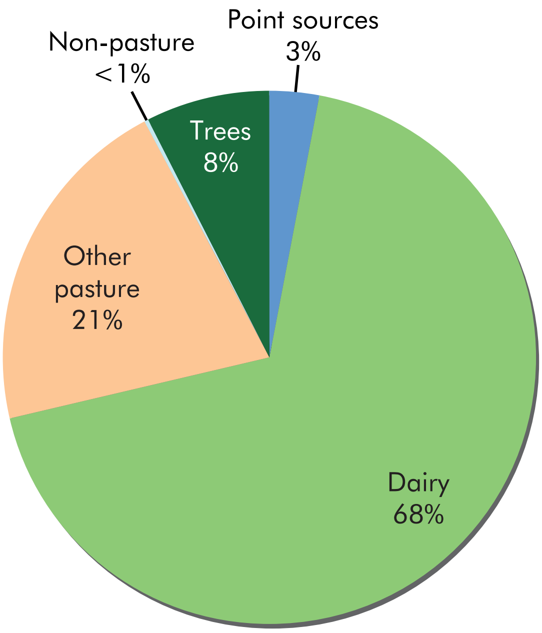
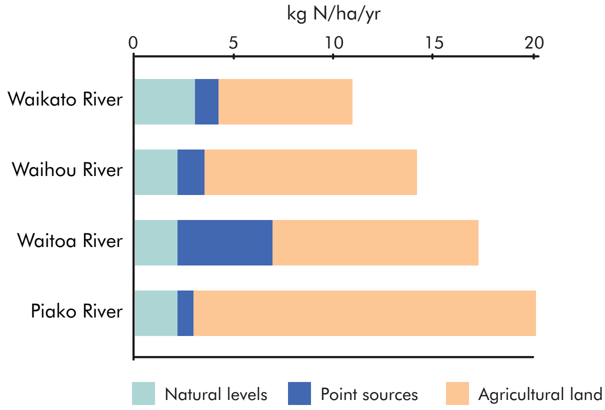
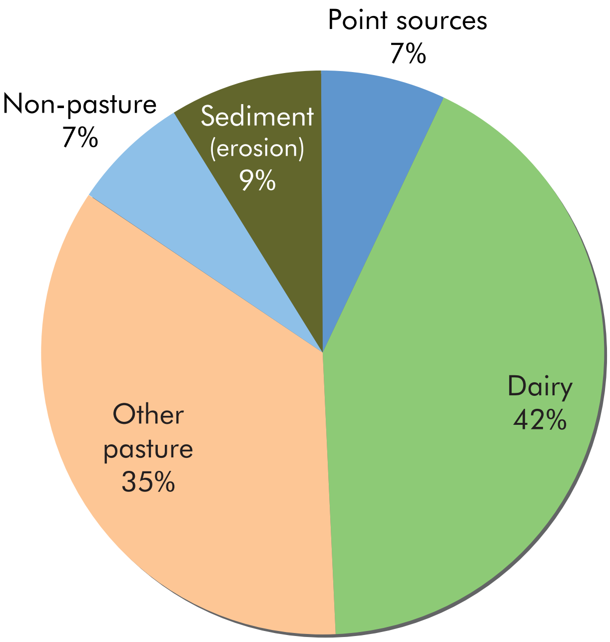


Figure 26 **Nitrogen loads to rivers in the Waikato region**[52]



Over the entire region, the total phosphorus lost to streams from dairy farming (42 per cent) is more than that from other farm types (35 per cent). Point sources such as factories are now responsible for only a small amount of total phosphorus in Waikato waterways (see Figure 27).

Figure 27 **Sources of phosphorus entering streams in the Waikato region**[53]



[51] Based on SPARROW modelling data provided by NIWA. See Elliott et al., 2005. Estimation of nutrient sources and transport for New Zealand using the hybrid mechanistic-statistical model SPARROW, Journal of Hydrology (NZ) 44 (1):1-27.
[52] Environment Waikato Indicator for Sources of Nutrients in Rivers.
[53] Based on SPARROW modelling data provided by NIWA. See Elliott et al., 2005. Estimation of nutrient sources and transport for New Zealand using the hybrid mechanistic-statistical model SPARROW, Journal of Hydrology (NZ) 44 (1):1-27.

Urban areas also contribute nutrients to waterways, mainly from sewage treatment plants. However, with advances in wastewater treatment technology, the contribution of nutrients from urban areas is now relatively small and decreasing. Hamilton City Council recently spent over $15 million upgrading the city's sewage treatment system to remove nutrients. It is estimated that this improvement will remove about 460 tonnes of nitrogen that would otherwise have reached the Waikato River every year[54]. This reduced the annual N loss for Hamilton City from about 67 kg N/ha to about 20 kg N/ha. By comparison, sheep and beef farms leach an average of 10 kg N/ha and dairy farms an average of 40 kg/ha.

Urban areas make up only one per cent of the total land area of the Waikato region, compared with 56 per cent of the total land area in farming. Because of its smaller area, urban run-off contributes only a small proportion of the total nutrient load in Waikato waterways.

Irrigation and other water removal from waterways can indirectly increase nutrient levels. This is because as the volume of water in the waterway drops, its capacity to dilute nutrients is also reduced.

The link between greater nutrient loss and intensive land use is seen nationally. A report by the Parliamentary Commissioner for the Environment[55] found that groundwater quality is decreasing in more intensively farmed regions, including Canterbury, Hawkes Bay and Waikato. It also concluded that throughout the country, water quality is poorer in lowland streams and rivers draining pastoral catchments, and getting worse. Nationwide, pastoral land use is estimated to contribute 70 per cent of total nitrogen to the coast[56]. Dairying contributes over half of this load, despite occupying just seven per cent of the country's total land area.

National trends in eiver quality over a period 1989 to 2005 in river quality reveal a pattern of decreasing ammoniacal nitrogen and BOD consistent with better management of point source pollution. However, increasing trends in dissolved and total phosphorus and total nitrogen combined with a strong correlation with the extent of pastoral land cover indicate the need to better manage non point source pollution, in particular from farming activities. The Waikato region is strongly represented in this negative trend.[57]

The Ministry for the Environment, New Zealand State of the Environment report (2007) states that intensification of pastoral farming is occurring to the detriment of soil, water and air quality. The report states that soils under pasture generally have higher nutrient levels, and under dairying some soils are high in phosphate and have nitrogen levels reaching saturation point. Increased stock numbers result in more soil compaction which reduces pasture growth and increases run off. Forty three per cent of rivers and 40 per cent of New Zealand lakes are in catchments that are predominantly in pastoral agriculture. Nitrate and phosphorus levels in these waters are above the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines and indicate a long-term trend in nutrient enrichment.

Trends in intensification

Dairy farming is intensifying in the Waikato region. In the 10 years from 1997 to 2007, the number of dairy cows in the region increased by over 100,000 to a total of 1,082,244[58]. The average stocking rate rose from 2.7 cows/ha in 1996/97 to 3.02 cows/ha in 2006/07. This translates to an additional 30 cows for every 100 hectares farmed.

Figure 28 shows changes in dairying since 1998 up to 2001 and 2007. The area under dairying (and intensity of use) has increased. Increased per hectare production is also the result of factors such as increasing use of brought in feed (Figure 29) which is an additional sorce of nutrient and further intensifies the pressures on the land.

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54 Hamilton City Council data.
55 Parliamentary Commissioner for the Environment, 2004. Growing for Good. Office of the PCE, Wellington.
56 Elliott et al., 2005. Estimation of nutrient sources and transport for New Zealand using the hybrid mechanistic-statistical model SPARROW, Journal of Hydrology (NZ) 44 (1):1-27.
57 Scarsbrook, M. 2007 State and Trends in the National River Quality Network (1989 – 2005). Report to the Ministry for the Environment ME 778.
58 Livestock Improvement Corporation figures from 1996/97 to 2006/07.

Figure 28 **Proportion change in Waikato dairy figures since 1998 to 2001 and 2007[59]**

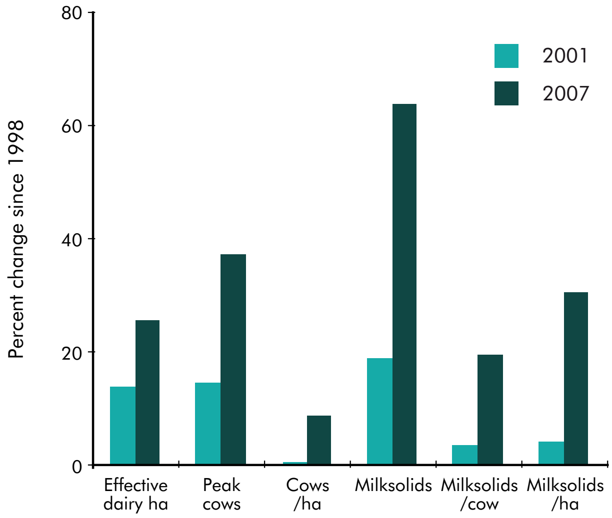
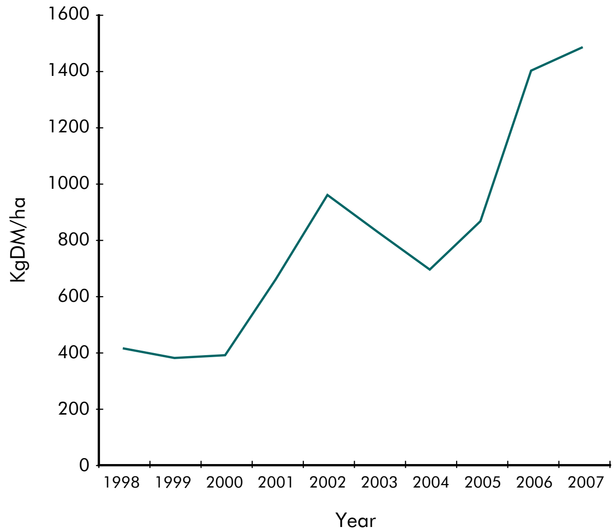


Figure 29 **The increase in brought in feed (as drymatter) on Waikato dairy farms since 1998[60]**



These trends are reflected nationally and are projected to continue. MAF predicts a further 3.5 per cent increase in the national dairy herd between 2005 and 2009[61].

In general, as stocking rates increase on grazed pasture, so too does the potential for increased nitrogen losses and nitrogen levels in the streams can increase (see Figure 30).

The amount of nitrogen leaching from both dairy and drystock farms in the Waikato region is estimated to have increased by 25 per cent between 1997/98 and 2003/04[62]. Additional nitrogen leaching is due to an increase in feed grown, promoted by fertiliser application, which results in more stock and more nitrogen being deposited on the pasture in urine[63].

Changes in land use can lead to dramatic increases in the amount of nutrients entering a stream or river. For example, a 36,500 hectare pine forest in the upper Waikato catchment is estimated to leach 48 tonnes of nitrogen and 3 tonnes of phosphate each year. Under current plans to clear this forest and convert it to dairy and drystock farming, the amount of nitrogen loss is estimated to increase by about 822 tonnes per year, more than a 17-fold increase[64]. Losses of phosphorus would increase by about 46 tonnes. Such a change in land use would increase average summer nitrogen levels in the Waikato River hydro lakes by 18-23 per cent. It would more than offset the benefit of the $15 million upgrade to Hamilton's sewage treatment plant, which cut the amount of N entering the river by 460 tonnes per year.

[59] Dairy NZ data.
[60] Dexcel data. Economic Survey of New Zealand Dairy Farms.
[61] Ministry of Agriculture and Forestry, 2005. Situation and Outlook for NZ Agriculture and Forestry. MAF Policy, Wellington.
[62] Derived by modelling based on data from MAF Farm Monitoring Survey.
[63] Menneer, J. et al., 2004. Land use impacts on nitrogen and phosphorus loss and management options for intervention. Client report prepared for Environment Bay of Plenty.
[64] Based on scenarios submitted by the prospective developer to Environment Waikato.

Figure 30 **Relationship between stocking rate and nitrogen yield[65]**

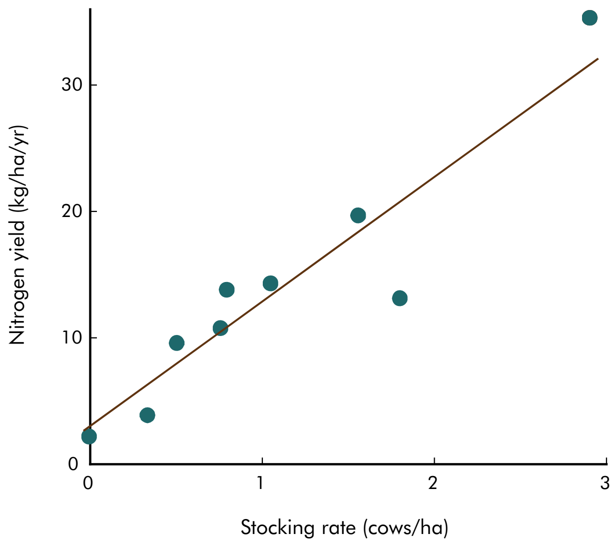
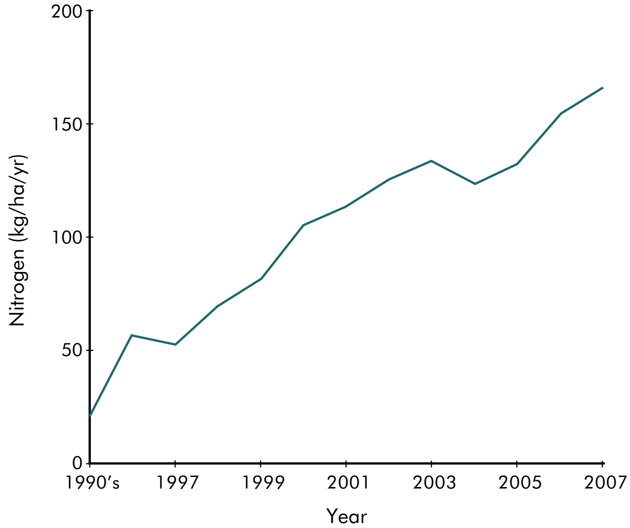


Figure 31 **Increase in N fertiliser use on Waikato dairy farms[66]**



Nitrogen fertiliser use

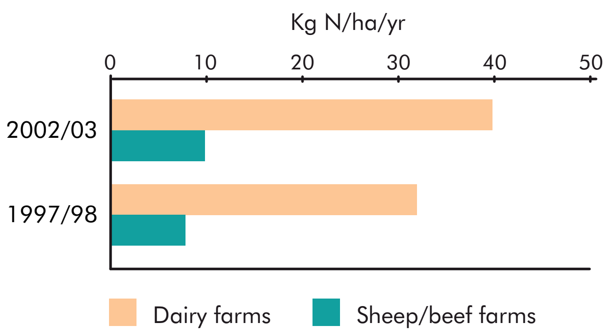
In line with stock numbers, fertiliser use has increased significantly on Waikato farms (see Table 3 and Figure 31). This represents a larger amount of nitrogen present in farm systems and the potential for greater leaching. Since 1990 there has been a seven-fold increase in application of nitrogen fertilisers on Waikato dairy farms (166kg N/ha in 2007).

The amount of nitrogen fertiliser used nationally has increased ten-fold since 1990 compared with just over double the use of super phosphate. The Waikato region is historically New Zealand's heaviest fertiliser user, only recently superseded by the Canterbury region. The highest rates of fertiliser are used in commercial vegetable growing. Within the pastoral farming sector, dairy farming uses the highest rates of fertiliser – an average of 101.5 kg urea/ha, vs 5.7 kg urea/ha for sheep and beef and 5.7 kg urea/ha for deer (2002 figures)[67].

However, fertiliser use in dry-stock farming is also increasing. The average amount of urea used on sheep and beef farms nationally rose from 0.7 kg N/ha to 5.7 kg N/ha (a 670 per cent rise) in just six years. Levels of up to 150 kg N/ha are now being used in trials, and there are reports of application rates as high as 400 kg N/ha/year[68]. Such practices, if widely adopted on sheep and beef farms, could have serious environmental consequences by dramatically increasing nitrogen leaching. Leaching rates from both dairy farms and sheep and beef farms have both been on the rise in recent years (see Figure 32).

[65] Based on Environment Waikato monitoring data and Agribase.
[66] Fertiliser industry and Dairy NZ data.
[67] Parliamentary Commissioner for the Environment, 2004. Growing for Good. Office of the PCE, Wellington.
[68] Stringleman H., 2005. Waikato station benefits from winter nitrogen, Country-Wide, Northern Edition, vol 27 (3):1,3.

Figure 32 **Average N leaching rates on Waikato dairy and sheep and beef farms**[69]



Implications

The implications of increasing stocking rates, fertiliser use and intensive grazing are that current trends towards nutrient enrichment of waterways and compaction of soil are likely to continue or worsen. It is also unlikely that there will be any improvement in faecal contamination of lowland waterways or sediment loads.

Those areas in dairying in the 1990s will need a reduction of about 20 per cent or more in current nitrate leaching to return to 1990 levels. Catchments that have had large scale changes to intensive land use (such as forestry to farming, or pasture to cropping) will require major changes in current farming practices if water quality is to be maintained.

In terms of nitrate in particular, surface water quality may continue to deteriorate for a time even if we start acting today because of the delays in groundwater travel time.

The longer the delay in taking action to reduce nutrient inputs to waterways, the worse the water will get before any improvements are seen.

Table 3 **National amounts of N and P fertilisers sold by the main fertiliser companies from 1990 to 2005**

		Phosphate	
Year	**Urea (000t)**	**Super (000t)**	**DAP and MAP(000t)**
1990	50	700	78
1995	98	900	210
2000	300	1380	170
2005	580	1640	322

[69] Judge, A. and Ledgard, S., 2004. Nutrient budgets for Waikato dairy and sheep/beef farms for 1997/98 and 2002/03. Environment Waikato Technical Report 2004/19. New data will be collected for 2007/08.

It's important

These environmental indicators are important because farming is a critical part of the region's economy, the future of which depends on the natural resources of clean water and healthy soil.

Dairying is important to the Waikato economy.

Economic value of farming

Farming is at the heart of the Waikato economy, contributing approximately 23 per cent of regional GDP when direct, indirect and flow-on effects are included (based on 2004 figures)[70]. More than 25,000 people were employed in farming or supporting industries in 2006 (see Table 4). This was just over 16 per cent of the region's workforce.

Agriculture has flow-on effects through the rest of the economy. As well as farm workers, the industry employs people in processing plants and in agricultural services. Wholesale and retail traders in towns across the region benefit from the farming sector, in terms of flow-on effects through the spending of farmers, farm staff and farm industry workers.

The dairy sector is the major earner within the agricultural sector. When processing of dairy products is included, dairy farming contributes close to $4.5 billion to the Waikato economy every year[71]. In fact, it has been estimated to bring up to $1.2 billion to the region every year at top milk pay-out rates[72].

The dairy sector is the fourth biggest employer in the Waikato region, employing nearly 11,000 people in 2006. Sheep, beef and mixed livestock farming contributes $594 million to the Waikato economy every year, employing over 5000 people (see Table 4).

Table 4 Numbers of people employed in farming and related industries in the Waikato region[73]

Farming sector	Number of people employed (2006 figures)
Dairy	10,950
Sheep, beef and mixed livestock	5,538
Horticulture	1,737
Services to agriculture	2,451
All other farming	1038
Meat and meat products manufacturing	2,370
Dairy products	1,677
Total	**25,761**

[70] Market Economics 2006. Waikato Region Economy Environment Futures Report. Environment Waikato Technical Report 2006/51.
[71] Hughs, W. 2007. Regional Economic Bulletin, July 2007.
Research/ Massey University. Palmerston North.
[72] Calculated using Livestock Improvement production figures and milk pay-out rates.
[73] Statistics New Zealand.

Need for healthy soil and water

Protection of soil and water is essential to ensure a viable agricultural sector for the future. Because of the economic significance of farming, the healthy soil and clean water that underpin farm production are a fundamental basis for economic and social well-being in the Waikato region.

It is vital that agriculture continues to thrive in the future. Adoption of recommended management practices on the farm to reduce environmental impacts can help achieve this.

Value of the clean, green image

Consumers in many of our key export markets are increasingly motivated by environmental concerns in their purchasing decisions. A loss of credibility about our environmental image could lead to multi-million dollar losses for our agricultural and horticultural export sectors, as well as our tourism industry[74]. This could have serious consequences for our regional and national economies.

Demonstrating a good environmental track record is therefore a sound investment both for the country and for an individual business. For example, British supermarket chains increasingly require suppliers to comply with environmental guidelines. Leading retailer Tesco requires all suppliers of fruit and vegetables to follow environmental standards, including specifications relating to fertilisers, pollution prevention and use of natural resources[75].

New Zealand's 'clean, green' image is estimated to be worth at least $240 million per year to the dairy industry in Asia and the Middle East alone. Federated Farmers have cited research putting an average annual figure of $40,000 on the value to each dairy farm of the clean, green marketing image[76].

'The environment is critical to the livelihood of our supplier shareholders, and New Zealand's clean, green image is widely recognised and valued by our customers.'

Fonterra, Annual Report 2001-2002

'Maintaining the quality of our water is fundamental to a sustainable dairy industry and to the country as a whole.'

Fonterra and the Environment – a sustainable New Zealand dairying industry 2007.

Pressure for environmental performance

While overseas consumers may have expectations about the way products are produced, currently it is internal domestic pressure which creates the greatest impetus for change. Domestic concern about soil and water management reflects perceptions around long-term productivity, ecological, cultural, recreational and aesthetic impacts.

Farms are businesses and, like any other business, they produce waste. For farms, some of these waste products occur in the form of excess nutrients, sediment and faecal matter generated as a result of productive activity. The cumulative effects of this are evident in the condition of waterways, which creates public pressure for rivers to be 'cleaned up' and for more

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74 Ministry for the Environment, 2001. Valuing New Zealand's Clean Green Image. Ministry for the Environment, Wellington.
75 Tesco Plc, Nature's Choice, www.tescocorporate.com/page.aspx 28 July 2005.
76 New Zealand Herald, 11/6/01.

regulation. However, because farming activities are spread out over a large area and most of the pollutants generated are invisible, the effects of farming on the environment are not always well-understood.

Unless there is recognition of the pollution risk generated by farming, steps to manage that risk may be too little or too late.

To maintain freedom to operate, and to protect their water and soil resources, farmers first need to be aware of the waste that their farm activities produce, what they can do to minimise it, and implement the necessary changes. As land use intensifies, extra attention to environmental performance will be required.

To put this in context, the waste generated by farming can be compared with that produced by other urban and land use activities.

- The Waikato region's combined dairy herd produces the same amount of faecal bacteria as 15 million people (117 cities the size of Hamilton).
- Twenty dairy farm oxidation ponds produce the same faecal load as all of Hamilton city (because the city sewage is disinfected).
- One dairy herd produces the same amount of bacteria as a town the size of Otorohanga.
- Dairy cattle in the Waikato region excrete about 20 times more nitrogen each year than people do. The average sheep and beef farm leaches more nitrogen than an average dairy farm (see Table 5). Although the amount of nitrogen leached per hectare is much lower for sheep and beef than for dairy farming, the larger size of sheep and beef farms means that the total yield of nitrogen is higher per property.
- Nutrient losses from horticulture can be very high on a per-hectare basis, depending on the crop grown. For example, early potatoes have been found to have a surplus of nearly half a tonne of nitrogen per hectare[77], though different studies have shown wide variations in actual leaching beneath vegetable crops.

Table 5 Average annual amounts of nitrogen leached from whole farms[78]

Farm type	Size (ha)	Nitrogen (tonnes)	Urea equivalent (tonnes)
Dairy	91	3.6	7.9
Sheep/beef	416	4.2	9.0
Potato	200	10.0	21.7

Pressure for improved environmental performance from government agencies, agencies representing the agricultural sectors and the public is growing.

[77] Crush, J. et al., 1997. Potential for nitrate leaching from different land uses in the Pukekohe area. Proceedings of the New Zealand Grasslands Association 59: 55-58.

[78] Farm size data from MAF Farm Monitoring Survey. Data for sheep and beef and dairy farm leaching from AgResearch. Data for potato leaching from Crush et al. 1997. Potential for nitrate leaching from different land uses in the Pukekohe area. Proceedings of the New Zealand Grasslands Association 59: 55-58.

What's being done

A sustained and concerted effort is required to address some of the worsening trends that are apparent. Farmers, the industry and all levels of government have been engaged in actions to address the issues discussed in this report and safeguard the future of the farming industry.

What Environment Waikato is doing

The indicators show that in the Waikato region, the past approach has not succeeded in reducing nutrient levels in waterways and maintaining overall water quality. For that reason, different strategies are required and some of these have already been set in place.

Protecting Lake Taupo

Environment Waikato's proposed variation to the Waikato Regional Plan contains new policies and rules to manage land use in the catchment, with some farming practices now requiring consents. It also contains tighter controls for new urban development in the Lake Taupo catchment.

The proposed new rules include:

- limits on the annual average amount of nitrogen leached from rural land use activities – dairy and drystock farming will require resource consents
- limits on the amount of nitrogen leached from new wastewater discharges (on-site or community systems)
- a high standard of nitrogen removal required from wastewater systems near the lake
- nitrogen trading allowed between properties to provide flexibility for land owners to meet the new rule requirements.

Nutrient management plans

From 2006 across the whole region, a nutrient management plan of the type specified in Table 6 must be used to plan fertiliser application where nitrogen is being applied at rates greater than 60 kg N/ha/year.

Table 6 Nutrient management plan requirements for different land uses

Land use type	Nutrient management plan requirements
All land uses applying more than 60 kg N/ha/y	A nutrient management plan must be prepared that as a minimum, records the following information for at least nitrogen and phosphorus in units of kg of N and P per hectare per year: • inputs from fertiliser • inputs from other sources such as manures, green crops and soil mineralisation • outputs in product • results of soil testing for levels of available N and P • documentation of consideration given to climatic and soil conditions for the life of the crop to account for the effects of rainfall and irrigation on the potential for N and P leaching through the soil into ground and surface water • practices that will be implemented to reduce nutrient and sediment losses from the property and to avoid, remedy or mitigate adverse effects on the environment.
Pastoral	The nutrient management plan specified above must be developed based on the outputs of either Overseer (AgResearch nutrient budget programme) or any other nutrient management planning tool that meets specific criteria.
Fruit	The nutrient management plan specified above must be developed based on the outputs of either the Soil Plant Atmosphere System Model – 'SPASMO' (HortResearch nutrient budget programme) or any other nutrient management planning tool that meets specific criteria.
Commercial vegetable production, arable/mixed cropping and livestock or any other land use not otherwise captured in this table	From 1 January 2011, the nutrient management plan specified above must be developed based on the outputs of any nutrient management planning tool that meets specific criteria.

Other approaches

Environment Waikato will prioritise its catchment management and policy activities to better manage the adverse effects of agriculture on the region's waterways, recognising that agriculture is a significant contributor to the region's economy.

In addition to the focus on Lake Taupo and on nutrient management plans, Environment Waikato is taking the following approaches.

- Better monitoring of permitted activities – proactive monitoring of whether land owners are complying with the Regional Plan with respect to farm effluent disposal, stock in water bodies, vegetation clearance, fertiliser use, soil disturbance, culverts and bridges.
- Piloting integrated catchment management – the running of pilot programmes in two catchments of approximately 100 farms to see if lasting improvements in environmental quality can be achieved by combining the work of our river and catchment schemes with voluntary actions by farmers to reduce nutrient losses.
- Reviewing policy for the upper Waikato River – beginning work with farmers, iwi and users of the Waikato River to determine whether we need to change the permissive approach in our Regional Plan in order to maintain the river's current water quality in the stretch between the Karapiro River and Lake Taupo.
- Promoting best practice – working with the agricultural sector and central government to ensure that agriculture becomes more sustainable in the future. We will reinforce the need for a quadruple bottom line approach (which takes into account economic, social, cultural and environmental factors) to maintain productive soils and water quality standards.
- Continuing Clean Streams – continuing our current Clean Streams Project, which provides grants for fencing stream margins.
- Research and information gathering – continuing to support research by the agricultural sector into ways that it can reduce its impacts on the environment. We will also improve our ability to measure, forecast and model environmental trends, so that the community is more aware of the trade-offs that occur between economic and environmental well-being when decisions are made about how land and water are used.
- Periodic collections of unwanted agrichemicals have been undertaken in the Waikato region since 1992. Currently facilities to enable farmers to safely dispose of unwanted agrichemicals exist at some regional transfer stations. Since 1992, Environment Waikato has collected in excess of 100 tonnes of unwanted agrichemicals

What others are doing

Farmers are increasingly becoming aware of the importance of environmental management and are taking positive action on their land. Many farmers are already decreasing their environmental impacts by fencing and planting stream banks, or by retiring steep or marginal country from grazing. These initiatives are supported by farmer representative groups, and by a range of industry, community and other organisations throughout the rural sector (see finding out more).

The dairy industry has shown leadership through involvement in the Dairying and Clean Streams Accord, and developing the Dairy Industry Strategy for Sustainable Environmental Management.

Other sector organisations are also actively investigating tools and practices to reduce the adverse effects of land use on the environment. Industry extension bodies are raising awareness of the issues and increasing support for the adoption of improved land management practice. There are quality assurance systems, awards and learning events that recognise and promote good environmental management on farms.

For example, the New Zealand Farm Environment Award Trust, which began in the Waikato region and now operates in many other regions, runs the Ballance Farm Environment Awards to identify and recognise best practice in environmental management on working farms. It has also produced publications about key practices and ran interactive learning events under its 'Learning from Leaders' project to encourage farmers to grapple with issues and management practices with input from leading farmers in this field.

The Sustainable Water Programme of Action

Under this programme, the government has agreed to a new strategy to improve the management of fresh water. The strategy focuses on three national outcomes for freshwater.

- Improve the quality and efficient use of freshwater by building and enhancing partnerships with local government, industry, Maori, science agencies and providers and rural and urban communities.
- Improve the management of the undesirable effects of land use on water quality through increased national direction and partnerships with communities and resource users.
- Provide for growing demands on water resources and encourage efficient water management through increased national direction, working with local government to identify options for supporting and enhancing local decision making, and developing best practice.

The package of actions identified includes a proposal for more national direction (such as national policy statements and identifying at-risk water bodies) as well as more tools for local government to manage water quality and water allocation.

As part of the sustainable water programme of action, a national stocktake and assessment of environmental initiatives in freshwater management has been undertaken. This shows that many different primary-industry sectors are engaged in environmental management initiatives (see examples in Table 7). Note that many individual companies also run quality assurance systems, including meat companies and merino fibre companies. In addition, all regional councils undertake a number of approaches including producing and providing information, funding work, facilitating group action and assistance with property planning.

Table 7 Examples of sector initiatives to address water quality[79].

Lead organisation	Programme	Sector
Fonterra	Dairying and Clean Streams Accord	Dairy farmers supplying Fonterra
Dairy industry	Dairy Industry Strategy for Environmental Management	All dairy farmers
Meat and Wool NZ	Monitor Farms – environmental module	Meat and wool farmers
NZ Deer Industry Association	DeerQA	Deer farmers
Zespri	Zespri System	Kiwifruit production
Biodynamic and organics	Range of certification systems and new organic advisory service	Pastoral, horticulture, service providers
NZ Winegrowers	Vineyard programme	Grape growers
International	EUREPGAP	All fruit exports to the EU
Horticulture NZ	NZGAP	Horticulture
FertResearch	Code of Practice for Fertiliser use	Range of primary producers
Landcorp Farming	Farm Pride	Range of farm types
NZ Forest Owners' Association	NZ Forest Code of Practice and Forest National Standard	Production forestry

The Dairying and Clean Streams Accord

The dairy industry has recognised the importance of managing the farm environment. The Dairying and Clean Streams Accord aims to reduce the impacts of dairy farming on New Zealand waterways. Signed in 2003, the accord is an agreement between Fonterra Cooperative Group, regional councils, the Minister for the Environment and the Minister of Agriculture and Forestry. It sets environmental performance targets for dairy farmers to meet.

> *'An industry-backed Accord to improve the environmental performance of dairy farming sends a strong message to the public and to domestic and international consumers, that environmental management is an integral and important component of the dairy industry.'*
>
> *The Dairying and Clean Streams Accord, 2003*

[79] Adapted from Harris Consulting 2006 Water Programme of Action. Stocktake of Environmental Initiatives in Freshwater.

Performance targets specified in the accord are:

- exclude dairy cattle from 50 per cent of streams*, rivers and lakes and their banks by 2007, and 90 per cent by 2012
- 50 per cent of regular crossing points to have bridges or culverts by 2007, 90 per cent by 2012
- all farm dairy effluent discharges to comply with resource consents and regional plans
- all dairy farms to have systems to manage nutrient inputs and outputs in place by 2007
- 50 per cent of regionally significant wetlands to be fenced by 2005, 90 per cent by 2007.

Excluding cattle from streams is part of the Clean Streams Accord.

*Defined in the accord as 'deeper than a 'Red Band' (ankle deep), 'wider than a stride' and permanently flowing'. Note that many Waikato streams do not fit the accord definition but would benefit from stock exclusion.

Progress towards these targets is monitored through Fonterra's On-farm Environment and Animal Welfare Assessment. Results for the Waikato region are shown in the tables below, along with results from Environment Waikato's compliance monitoring of effluent resource consents. Note: crossing points were not audited due to small sample size[80].

The 2007 accord target for excluding stock from 50 percent of waterways has been met. Twenty three per cent of dairy farms with waterways are yet to exclude stock (Table 8a). This is a total of about 1,600 kms of unprotected waterway. These waterways can still potentially be contaminated and this has downstream impacts on other farmers trying to improve water quality.

There has been a steady increase in the number of dairy farms with nutrient budgets (Table 8a). However, the extent to which this nutrient information has been used to decrease losses to the environment is not yet known.

Table 8 Progress towards the Dairying and Clean Streams Accord targets

8a – Target achievement as surveyed in the On-farm Environment and Animal Welfare Assessment

		Per cent achieved			
Accord action area	**Relevant target**	**2003/04**	**2004/05**	**2005/06**	**2006/07**
Percent of 'accord-type' waterways with no cattle access	Cattle excluded from 50 per cent of accord rivers by 2007	57	63	67	77
Percent of farmers that have completed a nutrient budget	100 per cent of farms have nutrient management plan by 2007	18	18	32	64

8b – Target achievement as determined through farmer compliance checks by Environment Waikato.

Accord action area	**Relevant target**	**Compliance (per cent)**	**Per cent achieved**		
			2005/06	**2006/07**	**2007/08**
Percent of inspected farms complying with dairy effluent resource consent conditions	100 per cent compliance immediately	Full compliance	24	14	10
		High level of compliance	27	39	49
		Partial compliance	26	33	28
		Significant non-compliance	23	14	13

The level of compliance with dairy effluent consent conditions is very poor despite an increase in Environment Waikato's monitoring and court fines of $7,000 to $35,000.

[80] Fonterra, Ministry for the Environment, Ministry of Agriculture and Forestry and Local Government NZ, 2006. The Dairying and Clean Streams Accord: Snapshot of Progress 2004/05. Ministry for the Environment, Wellington.

In recognition of the gap between current and target uptake of nutrient management planning, the Accord partners have identified this as an urgent priority.

Dairy Industry Strategy for Sustainable Environmental Management

The Dairy Industry Strategy for Sustainable Environmental Management was released in 2006.

The strategy's vision is 'one of enjoyable, profitable dairy farming that looks after the environment for future generations of farmers and the wider New Zealand public'. The objectives are to:

- establish the importance of environmental issues and action within the industry
- participate as a responsible member of the community in the regulatory process to ensure regulation is informed, scientifically based and appropriate to the circumstances
- show progress in environmental management and efficient use of resources
- develop the tools and knowledge for effective management of the environmental impacts of dairying.

Its key priority areas for the next 10 years include:

- nutrient losses of nitrogen and phosphorus to water
- microbial contamination of surface water and
- availability of water for dairying.

The strategy outlines three outcome areas to achieve its priorities:

- leadership and engagement
- action
- research.

Leadership at all levels is aimed at ensuring the industry is an active and respected participant in environmental management, and ensuring farmers are aware of the industry's approach.

The strategy incorporates the targets of the Dairying and Clean Streams Accord, and specifically identifies progress towards these targets on a broad front as one of its action priorities. Others include refining the recommended tools and options for farmers to manage impacts on the environment, and making significant gains in some target catchments where water quality objectives are not currently being met.

The Dairy Industry Strategy for Sustainable Environmental Management signals an ongoing and significant effort into research that will deliver farmers more cost-effective management options for reducing their impacts on the environment. Research goals include developing techniques to achieve a 50 per cent reduction in N and P loss and a reduction of microbial contaminants, so that water leaving the farm is suitable for contact recreation. There will also be greater emphasis on measuring environmental performance on farms, and developing more quantitative approaches to environmental planning.

In recognition of the urgency of lifting the numbers of dairy farmers using nutrient budgets or nutrient management plans, the dairy industry is showing leadership in working with the fertiliser industry to get rapid uptake of nutrient budgeting as a priority action for the first implementation period. There is also an emphasis on clearly defining the tools and options that the industry will promote to farmers to make significant progress towards the water quality priority outcomes. Dexcel, as the industry's primary extension arm, is coordinating these efforts.

Primary Sector Water Partnership

The major primary sector organisations have grouped together to develop a collective plan to address water management issues. They have set targets for the adoption of good practice by 2010-2016 for nutrient and water use, and to minimise sediment and microbes in waterways. These are voluntary targets relying on self-management as the primary means for achieving change.

Cadmium in soils

A cadmium working group is undertaking an assessment of cadmium accumulation in New Zealand agriculture. The Ministry of Agriculture and Forestry (MAF) convened the working group, which is assessing potential risks to human health, export trade, and land use flexibility. Members of the working group include representatives from MAF, Ministry for the Environment, New Zealand Food Safety Authority, Arable Food Industry Council, Horticulture New Zealand, Dairy InSight, Fonterra, Meat and Wool New Zealand, New Zealand Fertiliser Manufacturers' Research Association (FertResearch), and three regional councils (Environment Waikato, Environment Canterbury and Greater Wellington).

Research efforts

Research continues into methods of farming that can maintain profitability while reducing the impact of farming on the environment. This is revealing many cost-effective ways for farmers to address some of the priority concerns (see recommended practice on the farm).

Some of these are mitigation or interception techniques (for example NIWA research into best practice in riparian and wetland management), while others have a focus on input efficiency and reducing contaminants at source (for example, AgResearch work on the most efficient times and rates for fertiliser N or effluent application). Yet others provide tools for on-farm monitoring of soil and water quality (for example Landcare Research's Visual Soil Assessment). As farming intensifies, it will become relatively more important to address the sources of contaminants, since strategies for interception or buffering of waterways have more uncertain outcomes as contaminant loads increase[81].

One report summarised the current available technologies and best management practices for the dairy industry, and their location on the development continuum from underpinning research about the concept, through to adoption by farmers (see Table 9).

There are also trials that aim to bring together different options in a farm systems context. For example, the Resource Efficient Dairying (RED) trials in Hamilton, funded by FoRST and conducted by Dexcel, are comparing a number of intensive dairy systems in terms of both production and losses to the environment[82]. There is a focus on the potential for alternative feeds to reduce the N-content in urine.

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[81] De Klein, C. 2005. Mitigating envrionmental impacts of dairy farming in NZ – inventory of research efforts and currently available mitigation strategies. Working Paper 8. State of Research, Knowledge and BMPs. Client Report prepared for the Dairy Environment Review Group.

[82] Dexcel, 2006. Dexcelink Spring 2006 edition. Dexcel, Hamilton.

Table 9 **Research efforts and currently available mitigation strategies to reduce the environmental impacts of dairy farming[83]**

	Management Target						
Development stage	**Energy and water use**	**Soil**	**Feed**	**Stock**	**Nutrients**	**Effluent**	**Contaminants**
Underpinning research			High sugar grasses Feed additives				Absorbent materials Deep rooting plants
Proof of concept		Shorter rotations Graze wet soils early	Condensed tannins		Urease inhibitors P fertiliser form		
Development of technology/BMP	IrriNet soil monitoring	Stand-off feed and wintering pads	Low N supplement		Nitrification inhibitors	Low rate systems	Denitrification wall
On farm testing				Stand-off feed and wintering pads			Effluent ponds
System evaluation						Deferred irrigation	Buffer strips Wetlands
Extension	Guide lines for efficient energy and water use				Nutrient budgeting Optimum N rates and timing	Optimum annual rates; split applications	
Adoption				Stock exclusion			

Work is ongoing at the Lincoln University Dairy Farm, funded by Dairy InSight, MAF, Lincoln University, Ravensdown and Environment Canterbury, to deliver top returns on capital, while remaining sustainable in all aspects. This has included intensive monitoring of N loss under different regimes, including the use of nitrification inhibitor technology.

The dairy industry has developed a catchment-focused monitoring programme, with five catchments located in diverse sites, including Toenepi in the Waikato region. This study has the goal of improved environmental outcomes resulting from adoption of best management practices and shown through long-term monitoring[84]. Desktop modelling is also being done to consider how strategies focused on one critical issue (nitrogen loss) impact on the farm business and on other environmental issues (such as P losses, and greenhouse gas emissions). This suggests that a package of measures is required to achieve the dual target of improving milk production while reducing total environmental impacts[85].

Hill country research into sustainable catchment practices has been conducted by AgResearch in partnership with NIWA at Whatawhata, where a long-term study is underway into the impact of different land management practices on waterways and biodiversity. AgResearch has also developed a method for matching soil types and land capability to management choices within a farm system context (Soils Underpinning Business Success).

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[83] De Klein, C. 2005. Mitigating envrionmental impacts of dairy farming in NZ – inventory of research efforts and currently available mitigation strategies. Working Paper 8. State of Research, Knowledge and BMPs. Client Report prepared for the Dairy Environment Review Group.

[84] Wilcock, R. et al., 2006. Dairy farming and sustainability: a review of water quality monitoring in five contrasting restions of New Zealand. Presented at the Water 2006 International Conference, 1-4 August, Auckland.

[85] De Klein, C. 2005. Mitigating envrionmental impacts of dairy farming in NZ – inventory of research efforts and currently available mitigation strategies. Working Paper 8. State of Research, Knowledge and BMPs. Client Report prepared for the Dairy Environment Review Group.

Recommended practice on the farm

Many farm management practices are known to effectively reduce the amount of nutrients and dirty run-off entering waterways. Farms can markedly reduce their impacts on the environment, and even increase their economic performance, by adopting these practices.

AgResearch modelling[86] for nutrient losses under various management practices indicates that widespread adoption of current recommended best practices that have minimal net cost or even enhance farm profitability could reduce nitrogen loss from dairy farms by around eight per cent and phosphorus loss by 40 per cent. These practices include avoiding N fertilisation in winter, land application of farm dairy effluent and maintaining optimum soil P status. More substantial changes that may require significant spending on farms (such as winter feed pad systems and nitrification inhibitors) could cut nitrogen losses by up to 44 per cent, while full riparian protection could reduce total P inputs by 20 per cent.

However, as nutrient inputs increase as a result of intensification and land use change, this may act to offset any reduction in nutrient losses through current recommended practices. If so, water quality could continue to decline in many areas in spite of best practice adoption. For example, concentrations of total nitrogen and total phosphorus in streams across the Waikato region increased by an average of 2 per cent every year between 1987 and 2007[87]. If this trend continued, the effect of an 8 per cent cut in N-loss from adopting some of the more straightforward current recommended practices would only last around six years. Because of trends towards more intensive land use and more conversion of forestry land to dairying, it is likely that more substantial changes in farm practice will be needed to maintain water quality in sensitive water bodies such as the Waikato hydrolakes[88].

Nutrient management

Fertiliser is among the largest farm expense items. Farmers can save money, and help to protect the environment, with sound nutrient management practices that match inputs to outputs and aim to retain nutrients within the soil profile for plant uptake.

Practices that reduce soil erosion and avoid excessive P levels in the soil (such as optimum fertiliser inputs) will help reduce phosphorus losses to waterways.

Some nitrogen losses can be avoided through fertiliser and cropping management. However, as most nitrogen loss occurs under cow urine patches systems to collect and manage effluent are required to protect water quality in sensitive catchments (such as stand-off or feed pads and ‘cut and carry’ systems). New technologies, such as nitrification inhibitors are also being developed to retain nitrogen in the soil profile over winter (the high risk leaching time).

Management options with the potential to markedly decrease nitrogen loss from farming activities are shown in Table 10.

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[86] Ledgard, S. and Power, I., 2006. Nitrogen and phosphorus losses from ‘average’ Waikato farms to waterways as affected by best or potential management practices. Environment Waikato Technical Report 2006/37.

[87] Vant, B., 2008. Trends in River Water Quality in the Waikato Region, 1987-2007. Environment Waikato Technical Report 2008/33.

[88] Vant, B., 2006. Pastoral farming and nitrogen loads to the Waikato River hydrolakes: results of four new scenarios including CHH conversions.

[89] Adapted from Menneer, J. et al., 2004. Land Use Impacts on Nitrogen and Phosphorus Loss and Management Options for Intervention.

Table 10 Management options to reduce nitrogen loss from farming[89]

Management option	Decrease in nitrogen leaching
Nutrient budgets	50–60 per cent
Feed pads (restricted grazing)	30–60 per cent
Cut and carry (zero grazing)	50–60 per cent
Use of nitrification inhibitors	30–80 per cent
Limiting N fertiliser application rates	10–40 per cent
Limiting N fertiliser use in winter	Up to 30 per cent
Split dressings	Up to 45 per cent
Strategic placement of fertiliser	Up to 24 per cent
Timing of crop cultivation	60–80 per cent
Planting cover crops (post-harvest)	60–80 per cent

Nutrient budgets

A nutrient budget combined with soil tests can be used to work out how much fertiliser is required for farm production. It calculates the total inputs of nitrogen and phosphorus to a farm, and then subtracts all losses. This gives the farmer an estimate of whether too many nutrients are being added to the farm, particularly in the form of fertiliser, and allows optimisation of farm management practices. Nutrient inputs can then be managed so that the optimal amount of nitrogen and phosphorus is added to the land. This can result in savings for the farmer in terms of reduced fertiliser, as well as benefiting the environment by preventing over-fertilising and loss of nutrients from the land. The major fertiliser companies offer nutrient budgets as part of their service.

Nitrification inhibitors

Chemicals known as nitrification inhibitors can decrease the rate at which ammonia is converted to nitrate in the soil. Nitrate is more soluble than other forms of nitrogen, and so passes easily through the soil and into groundwater. Nitrification inhibitors slow the rate that nitrogen in urine is converted to this soluble nitrate form, instead retaining more as ammonium, which is still plant-available but is held in the soil.

Nitrification inhibitors are used directly on the paddock, sometimes incorporated into fertilisers. Experiments have shown reductions in nitrogen loss from soil when nitrification inhibitors are used[90]. This includes less nitrate loss to groundwater and less release to the atmosphere of nitrous oxide (a greenhouse gas). Nitrification inhibitors decrease requirements for fertiliser, since more nitrogen is retained in the soil over winter for plant use in spring, and overall pasture production increases.

Fertiliser timing, rates and placement

Attention to when, where and how much fertiliser is applied can help reduce losses by ensuring fertiliser availability closely matches uptake by pasture.

Soil testing is recommended to ensure that optimum soil fertility levels are not exceeded, as this represents wastage of valuable nutrients and can increase the amount of nutrients leaching from soils, or carried to waterways attached to soil particles.

The use of split dressings of N fertiliser (applying N 'little and often') can balance fertiliser inputs with pasture uptake, leaving little surplus available for leaching.

Client Report Prepared for Environment Bay of Plenty. Nitrification inhibitor data from Di, H. and Cameron, K., 2005. Reducing environmental impacts of agriculture by using a fine particle suspension nitrification inhibitor to decrease nitrate leaching from grazed pastures. Agriculture, Ecosystems and Environment 109:202-212.

90 Di, H. and Cameron, K., 2005. Reducing environmental impacts of agriculture by using a fine particle suspension nitrification inhibitor to decrease nitrate leaching from grazed pastures. Agriculture, Ecosystems and Environment 109:202-212.

Another useful strategy is to avoid application in wetter conditions and low-growth periods such as summer drought or winter cold (when soil temperature is less than 6°C). Fertiliser applied during winter months when pasture is not growing will not be taken up, and is likely to simply be washed through the soil to groundwater, or drain to streams.

Only low rates of N should be applied in areas with light soils and mole or tile drainage, where leaching risk is higher.

Fertiliser (N and P) should not be placed in non-productive areas or adjacent to waterways. Separate fertiliser regimes should be maintained for different classes of land, so that the best use is made of fertiliser investment through concentrating it on the better class of land. Care should be taken when fertilising steep slopes near waterways, or applying aerial fertiliser.

Spreadmark certified operators have quality assurance measures in place for precision fertiliser application.

Feed and supplements

Nitrogen loss has been shown to decrease through the use of:

- low-N supplements such as maize silage
- pasture plants with high tannin levels that result in less N excreted in urine.

High tannin pasture species also reduce methane production and hence the rate of greenhouse gas emissions from cows.

Riparian fencing and planting

Fencing waterways on farms can reduce the amount of phosphorus, sediment and microbes entering water. Fences prevent stock from entering and dirtying the water, while plants growing behind the fences stabilise stream banks and block the movement of particles from land into streams.

- Even without planting, fencing off streams reduces faecal coliforms reaching the water by 35 per cent, as well as protecting banks from erosion.
- In ideal conditions, fenced grass riparian strips can reduce:
    - sediment entry to streams by over 80 per cent
    - dissolved P entry by over 50 per cent
    - nitrate-N by over 60 per cent[91].

Planting riparian strips also helps restore the ecology of streams by providing shade that cools the water and suppresses aquatic weed growth. When combined with weed and pest control, planting can enhance habitat on land for native insects and bird life.

However, riparian planting is less successful in reducing nitrate entry to streams where there are no wet soils bordering the stream channel where N can be released back to the air. This is because nitrate tends to pass into groundwater from the paddock surface through the soil, rather than moving over the surface attached to particles as phosphorus does. Therefore, riparian planting alone will not be sufficient to solve the problem of nutrient build-up in Waikato waterways.

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[91] Smith, C., 1989. Riparian pasture retirement effects on sediment, phosphorus, and nitrogen in channelised surface run-off from pastures. New Zealand Journal of Marine and Freshwater Research 23: 139-146.

Increasing numbers of farmers in the region and around the country are protecting streams on their property with riparian fencing and plants. Over 400 farmers already participate in the Clean Streams Programme with Environment Waikato. As of June 2005, 434 kms of stream bank have been protected under this scheme.

Some financial and practical assistance from Environment Waikato is available for landowners in priority locations wishing to fence off streams on their land. Environment Waikato's 'Clean Streams' project covers up to 35 per cent of eligible farmers' costs for fencing and planting waterway margins.

Riparian fencing protects banks from erosion and improves water quality and habitat.

Seepage areas and wetlands

Seeps and wetlands act like the 'kidneys' of the land. They naturally remove pollutants from farm run-off by filtering and cleaning the water that flows through them. Sediment and faecal material are trapped in the wetland vegetation, while the microbes living in wetland soils remove nitrate from farm run-off. Very high levels of nitrate removal have been recorded for wetland areas (up to 90 per cent). However, for wetlands to work effectively they need to be retained (unaffected by drainage), adequately sized for the catchment area, and fenced to allow growth of wetland vegetation that will slow water flow.

A carbon-rich form of vegetation (such as raupo) increases the effectiveness of wetland bacteria that act to remove nitrogen. Abundant carbon also reduces the proportion of harmful greenhouse gases emitted by wetland areas.

Wetlands can be constructed at drain outlets, or at the base of catchment areas to remove nitrogen before drainage water flows into downstream waterways. A wetland of around 2-5 per cent of the total catchment area draining into it is recommended for significant N-removal. Constructed wetlands are receiving attention as an effective mechanism for protecting sensitive downstream receiving waters such as lakes.

Retaining and fencing naturally occurring wetlands and seeps is a much lower cost option than a constructed wetland. Fencing out swampy areas can also prevent stock losses. If weeds are controlled, these areas can quickly become attractive features in the farm landscape, and provide valuable habitat for fish and bird life as natural wetland vegetation re-establishes. Tree-planting is generally not recommended around wetland margins as trees can dry out the soils and shade the carbon-rich wetland species. Locally occurring reeds, rushes, and sedges are more suitable.

Fenced and grassed drains

Many drains on farms empty directly into waterways and can be a major source of pollutants in some areas. Poorly managed drains can act as contamination 'highways', providing shortcuts into waterways for nutrients, bacteria and sediment. A well-managed drain can aid nutrient removal and form an important habitat for fish and other water life.

Keeping drains fenced and well vegetated can considerably reduce the amount of nutrients discharged to waterways. Fencing banks prevents stock trampling and erosion, reducing the frequency of drain maintenance required. Vegetation such as rough grass traps farm nutrients and slows the water flow so that nutrient removal processes can occur (in this case drains can act like mini-wetlands).

Mechanical drain cleaning should be kept to a minimum, and spraying of drain vegetation only carried out along a portion of the drain at any one time.

Consult your drainage authority regarding any significant changes to your drain management regime (for example, planting or deepening).

Tracks and raceways

Poorly designed and maintained tracks and raceways can collect and channel farm run-off into the nearest waterway, carrying sediment, nutrients and effluent into the water.

Management of run-off from raceways helps to improve water quality.

Well-designed raceways divert run off from the track onto paddocks rather than into waterways. As well as helping the environment, this also prevents channelling and eroding, saving on track maintenance.

An important consideration for track design and minimal maintenance is the shaping of the track to direct water off the track surface and into rough grass areas (for example, with a crown on a flat slope, or correct cambering and culverts on a slope). Regular cut-offs (small channels on the side of the track) will remove water, again directing it into the paddock or rough grass alongside. This prevents scouring of the track surface and excessive erosion.

Approaches to waterways are particularly important – if there is an area of fenced vegetation or small wetland alongside the waterway, track run-off should be diverted into this area so that dirty water does not run directly into the stream.

Bridges and crossings

Studies indicate that stock directly depositing their waste into waterways has an equal, if not greater, impact on water quality than farm run-off. Cattle are 50 times more likely to void in the stream than on the race. This shows the benefit of a crossing in reducing the amount of contaminants entering the water. Farmers also get the benefits of saving time and stress in getting cows to and from milking, and being able to get cows across channels during flood flows.

Good bridge design includes a small lip to avoid effluent flowing off the sides into the waterway. Culverts need to be carefully placed so that fish can still migrate up through them. Placing the culvert into the stream bed so there is no 'waterfall' effect at the downstream end.

Wintering strategies

Keeping dairy cows off pasture during the wettest part of the year can substantially reduce the loss of nutrients from soil and avoid compaction. The options for wintering include:

- moving stock off-farm (although care is needed not to transfer the problem somewhere else)
- constructing a stand-off pad, wintering pad or wintering barn/herd home
- carefully controlling winter grazing to avoid pugging and nutrient loss.

Standing off

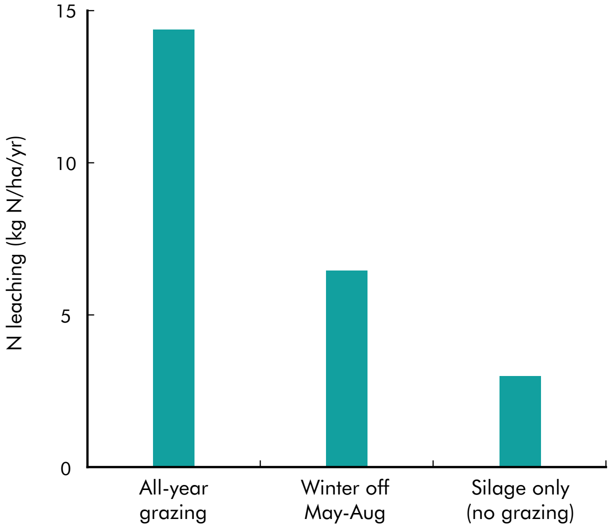
Stand-off pads are specially constructed areas where cows can be taken and held during wet periods. The effluent is collected and treated or applied to land when weather and soil conditions are suitable. Wintering pads combine a stand-off facility with feeding bins. Wintering barns or herd homes have these facilities inside a roofed or enclosed structure. Herd homes have a concrete slatted floor with bunkers underneath to collect and dry the effluent, resulting in solid manure that can then be applied to pastures or crops.

From an environmental point of view, removing cows from wet pastures reduces pugging and compaction damage and nutrient run-off during prolonged wet weather. There are fewer urine patches and nitrate leaching is reduced. Several recent studies have shown reductions in nitrate leaching of 50–60 per cent when dairy cows were stood-off on a pad (see Figure 31)[92].

Farmers with wintering barns have observed an increase in milk production, better cow condition and less animal health problems in addition to reduced pasture damage during wet periods. However, these facilities need to be carefully designed for animal comfort, to avoid lameness problems, and to fit in with farm business objectives and management practices.

With all pad designs, special attention is needed to effluent collection and treatment, to avoid the stand-off area becoming a nutrient loss 'hotspot'. There is usually a need to upgrade, or extend the existing farm effluent treatment system.

Figure 31 Decrease in nitrogen leaching from wintering off[93]



Standing cattle off pasture reduces nutrient leaching and soil compaction.

Grazing management

Careful grazing management can reap rewards for soil productivity and for water quality. Controlled grazing to maintain a dense sward reduces the area of bare ground by between 20 and 100 per cent[94]. This improves soil structure and infiltration, and dirty run-off is less likely. For cattle, sediment loss through run-off is reduced by up to 80 per cent under a scenario of low treading damage.

As well as the environmental benefits, this has long-term benefits for farm income, as pasture cover and soil productivity are maintained.

Cropping practices

Managing drainage and cultivation planting cover crops and reducing soil movement can dramatically reduce the loss of sediment and nutrients from soils cultivated for vegetables.

Vegetable growers have worked with Environment Waikato on a project funded by the Sustainable Farming Fund to produce a guide on best land management practice for their industry.

[92] Menneer, J. et al., 2004. Land Use Impacts on Nitrogen and Phosphorus Loss and Management Options for Intervention. Client Report Prepared for Environment Bay of Plenty.
[93] Ledgard, S. and Menneer, J., 2005. Nitrate leaching in grazing systems and management strategies to reduce losses. Invited review paper in: Developments in Fertiliser Application Technologies and Nutrient Management. Eds. L. Currie and J. Hanly. Occasional Report No. 18 of the Fertiliser and Lime Research Centre, Massey U:niversity, Palmerston North.
[94] AgResearch, 2003. Managing treading damage on dairy and beef farms in New Zealand.

Recommendations include[95]:

- leave fallow strips along watercourses and drains – this can reduce sediment entry to waterways by up to 50 per cent
- plant cover crops after harvest to decrease nitrogen leaching and soil loss
- retain crop stubble and residues on the soil to decrease erosion (cultivate in spring rather than autumn)
- test soils for nutrient levels, for optimal matching of fertiliser application to crop requirements
- construct silt traps or bunds to minimise soil loss.

Grazing of winter crops can also be carefully managed to minimise nutrient loss and soil damage. The most effective system is cut and carry, where the feed is transported to animals on a feed pad. Otherwise, on-off grazing, where animals are allowed to graze for up to four hours, and then removed to a stand-off area is also effective, as long as effluent from the stand-off area is collected and treated properly. Back-fencing should be practised when grazing crops in the field, to prevent pugging of already-grazed areas.

Effluent irrigation

Modifying the timing and rate of effluent irrigation to match soil conditions can increase the uptake of nutrients and thus reduce run-off.

Deferring irrigation during wet periods by storing effluent until soil conditions are drier is a key practice. This may require additional storage pond area but gives greater flexibility to fit in with farm operations and make the most of both the water and nutrient value of the effluent.

Irrigation equipment that applies effluent in a uniform pattern and at low rates can also markedly reduce run-off and leaching. For example, using a 'pod' type of sprinkler system (such as K-line) rather than a travelling irrigator substantially reduces losses of nutrients and bacteria to waterways[96].

Moving from pond systems to land application can be one of the most effective means of reducing phosphorus and ammonia levels in streams that currently receive pond discharges.

Using soils to their best advantage

Understanding soil types can help decrease the environmental impacts of farming while enhancing the farm business.

For example, poorly drained, heavy soils (see Figure 33) are easily overgrazed in wet conditions, as the soils are vulnerable to trampling damage. Run-off from these soils can be dirty, particularly if they are pugged. Fencing and planting the margins of streams and drains in areas with heavy soil allows a thick cover of grass to develop to filter dirty run-off before it reaches the waterway. These soils contribute less nitrogen to groundwater, because under the wetter soil conditions, nitrogen from urine is converted to gaseous forms that escape to the air.

Well-drained soils, on the other hand, are less likely to have dirty run-off and are less prone to compaction during wet conditions (see Figure 34). However, they are more likely to contaminate groundwater with nitrate, which is carried swiftly by rainwater through these permeable soils. Farmers with a high proportion of well-drained soils on their properties may need to look at using techniques (split dressings of N-fertiliser) that decrease the losses of nitrogen. Where free-draining soils occur around water bodies that are sensitive to nitrogen enrichment (such as some lakes), more dramatic reductions in N losses may be called for, requiring tools such as stand-off areas or 'cut and carry' feed pad systems in winter.

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[95] Pukekohe Vegetable Growers' Association et al., 1999. Doing it right. Franklin Sustainability Project guide to sustainable land management. Pukekohe Vegetable Growers' Association; Ministry of Agriculture and Forestry; VegFed; Agriculture New Zealand; Environment Waikato; Franklin District Council; Auckland Regional Council.

[96] Monaghan R. et al. 2005, Managing nutrient losses and greenhouse gas emissions from dairy farms within the Bog Burn catchment, Southland, in Proceedings of the Workshop 'Developments in Fertiliser Application Technologies and Nutrient Management', Massey University, Palmerston North, New Zealand, 9-10 February 2005.

Soils that are prone to erosion also require careful management to prevent sediment entering waterways. On steeper areas, these soils (which are often unproductive and grow pasture weeds) may be better retired and planted with a dense tree cover to prevent erosion and control weed growth.

Soil advisers can help farmers to map the soil types on their properties. This will assist with farm management decisions to make the most of the different soil areas.

Figure 33 Poorly drained soil types often have pale subsoils

Figure 34 Well drained soil types often have brown or orange-coloured subsoils

Finding out more

There are numerous printed and electronic publications available on recommended management practices.

Some of the comprehensive codes of practice and best-practice manuals include:

- Code of Practice for Fertiliser Use. Updated 2002. New Zealand Fertiliser Manufacturers' Research Association, Auckland. Now being revised and soon to be released as 'Code of Practice for Nutrient Management (With Special Emphasis on Fertiliser Use)'.
- Managing Farm Dairy Effluent and Farm Management Issues. Revised and updated 2006. Dairying and Environment Committee.
- New Zealand Deer Farmer's Landcare Manual. 2004. New Zealand Deer Farmers Association.
- Doing it right. Franklin Sustainability Project guide to sustainable land management. 1999. Pukekohe Vegetable Growers' Association and partners.

A number of short guides on specific topics are also available, for example:

- A Guide to Managing Farm Dairy Effluent. Dexcel and Environment Waikato.
- Minimising Muck, Maximising Money. Stand-Off and Feed Pad Design and Management Guidelines and Stand-Off and Feed Pad Case Studies. Dexcel.
- Clean Streams – A Guide to Managing Waterways on Farms. Environment Waikato
- The New Zealand Farm Environment Award Trust publications:
    - Getting Smart with Nutrients. A Guide to Good Nutrient Management
    - Growing Greener Grass. A Guide to Good Pasture Management
    - Low Impact Tracks and Races
    - Managing Natural Features on Farms
    - Winning Margins – Waterways on Farms
    - Whole Farm Sustainability.

Contact the above organisations, farm advisers or industry representatives for details. Much useful information is available from the Dexcel envirodirect website www.envirodirect.co.nz and the Environment Waikato website www.ew.govt.nz.

Summary

- There are deteriorating water and soil quality indicators, particularly for nutrient pollution, soil compaction, and soil contaminants.

- It is vital to have clean water and healthy soil for the well-being of our regional economy, to protect our lifestyle and environmental values, and to ensure options for present and future generations are not compromised.

- Different parts of the region will need different management approaches.

- Using recommended management practices can improve water quality and soil health as well as increasing farm profitability.

- Considerable effort is underway into research and on-farm improvements to halt and reverse environmental deterioration. A sustained effort will be required to implement and improve these initiatives, ensuring that farmers can continue to operate viable businesses into the future.

Environment Waikato
REGIONAL COUNCIL

For more information please contact us on
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www.ew.govt.nz

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