Most of us are proud of the environmental beauty and recreational opportunities afforded by the Manawatu-Wanganui region we inhabit. And the economic conditions necessary for our region's wealth and prosperity are based on our physical and natural resources. Although we may not feel we can do much about it, we also want some certainty that these natural resources we depend upon are in good heart and have the capacity to sustain our way of life for many generations to come.

But how do we know that there are fewer native birds out there than, say, 30 years ago? That our rivers run cleaner, that our hill country is more stable, our top soil is conserved and our air is pure?

The only way to be sure is to set up historical measures — scientific benchmarks — against which we can judge what we are doing to the world around us, and what it is doing to itself. Doing this systematically across a broad range of measures is a new development. It enables us to see where the effort needs to go at a regional level by all parties — councils, tangata whenua, community groups, scientists and individuals. If we are then able to act on this information we can all be empowered to make our environment a better place for the future. This book is an important measure of our changing landscape.

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Measures of a CHANGING LANDSCAPE

State of the Environment Report Manawatu-Wanganui Region 1999

MEASURES FROM A CHANGING LANDSCAPE

Measures from a Changing Landscape

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Christine Beech, Gabor Bekesi, Tony Gates, Hydrology Department staff, Sheila Jolley, John Phillips, Ross Quayle, Department of Conservation (p 35). Palmerston North Public Library, Whanganui Regional Museum.

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GENERAL MANAGER'S FORWARD

It gives me much pleasure to welcome readers to the first State of the Environment Report for the Manawatu Wanganui Region.

horizons.mw has a statutory function, prescribed by the Resource Management Act, to monitor the state of our environment. While we have undertaken such monitoring for a long time, our efforts have focused predominantly on water, partly reflecting our Catchment Board and Regional Water Board origins. This report demonstrates that in general terms those water resources are in reasonably good condition.

I would be quite delighted if we could give the same assurance about the land resources of our Region. Unfortunately I can't. This report shows that the major unresolved question about our environment is "are existing land use practices sustainable?". We do not have enough information to answer this. Much work has traditionally been done on hill country erosion and its prevention. Our most valuable land however is intensively used by industries such as horticulture and dairying, and we have little information as to whether such intensive practises are sustainable in the long term. This is an information gap that must be addressed.

horizons.mw is now placing greater emphasis on state of the environment monitoring than we did in the past, when consents, policy and compliance monitoring functions took greater precedence. We look forward to working alongside research organisations to answer the many questions that this report raises. In the medium term, answers to those questions will help us refine our resource management policy to ensure that sustainable management is the reality, not merely the ideal, for our region.

I thank all who have contributed to this report, and commend it to you, the reader. Please contact staff at horizons.mw if you want any further information about our environment. We will do our best to inform you.

Euan Dempsey
GENERAL MANAGER

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A SENSE OF PLACE

HOW THE LAND LIES

In a country that promotes and celebrates its natural beauty and diversity, Manawatu-Wanganui is a North Island region of physical contrasts as sharp as anywhere in New Zealand. Stretching from the dunelands bordering the Tasman Sea to the volcanic uplands, the unique mix that is Manawatu-Wanganui also includes considerable areas of uplifted ranges, steep papa country and rich alluvial plains. The Horowhenua Plains, that take in the towns of Levin and Ohau, are part of it. So too the Manawatu with its towns of Foxton, Shannon, Sanson, Feilding and Bulls. Through the Manawatu Gorge Manawatu-Wanganui extends to take in not only the provincial towns of Dannevirke, Woodville, Pahiatua and Eketahuna, but also for 40 km, the north Wairarapa Pacific Coast. Its boundaries contain extensive wilderness, intensive farming, a comprehensive city (Palmerston North), its smaller, historical neighbour, Wanganui and a string of other small rural towns including Taihape, Waiouru, Ohakune, Taumarunui and Ohura.

Like most parts of provincial New Zealand, the region is rich in river systems and agricultural production. But outside of its two national parks, Tongariro and Whanganui River, and four huge forest parks (Ruahine, Tararua, Kaimanawa and Pureora), it is limited in naturally occurring flora and fauna.

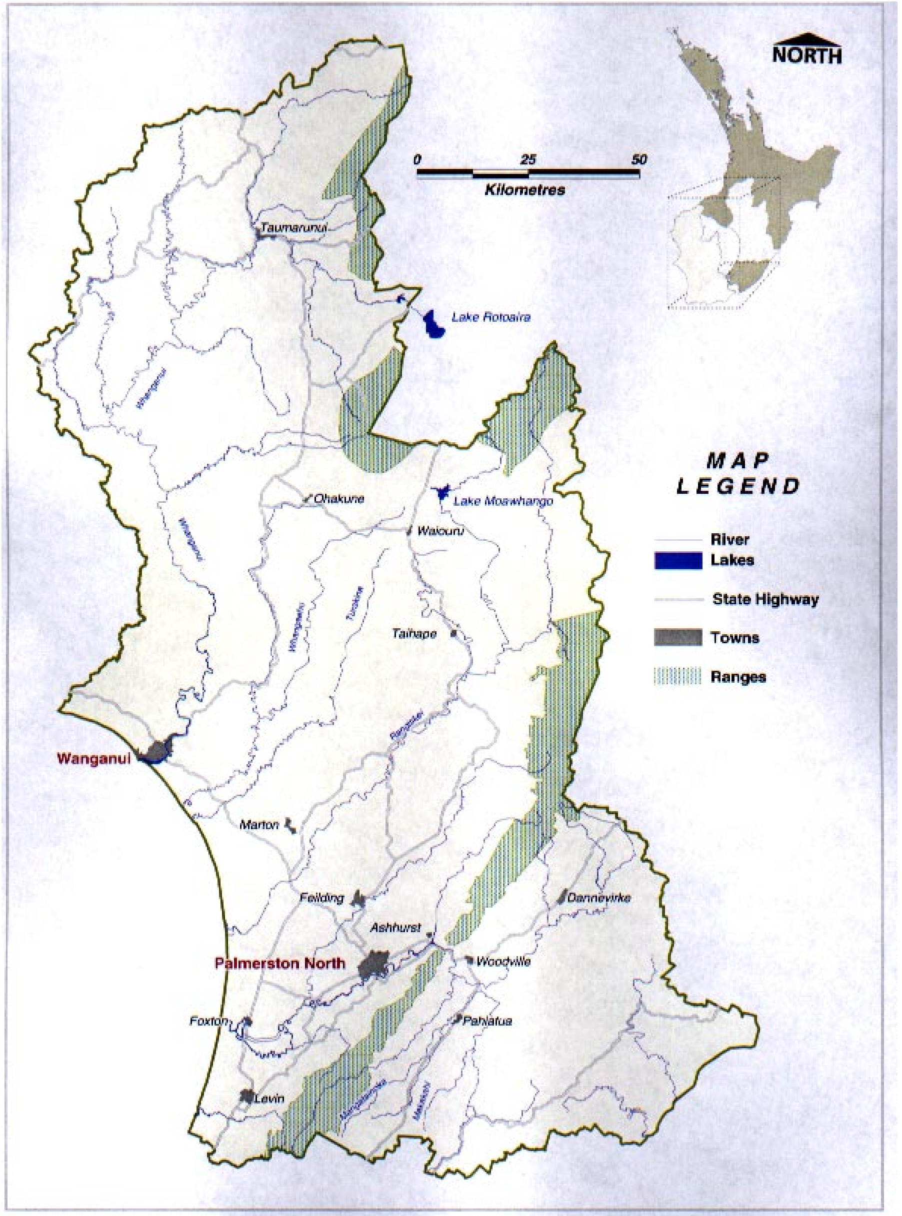
Climate range reinforces most forcefully ideas about Manawatu-Wanganui diversity, which has a marked west-east divide. With the backdrop ranges of Tararua, Ruahine and Kaimanawa buttressed against the prevailing westerlies, the west is generally adequately provided for with rain for most of the year. The ranges force moist air masses to rise and cool rapidly, releasing more of their moisture as rain. Annual rainfall in the Tararua and Ruahine Ranges approaches 3500 mm per year. Rainfall is relatively high in the upper Whanganui catchment adjoining the central Taranaki high country. Weather systems approaching from the north-west can bring heavy rain to this part of the region; falls of 100 mm per day are not uncommon. Average rainfall for Palmerston North is 995 mm, 906 in Wanganui.

Extreme rainfall has been recorded at highly localised spots, Arete Pt and Mt Dundas in the Tararuas. Here above the richly alluvial Horowhenua, rainfall can match the 10 metres a year boasted by the South Island's West Coast. However annual rainfall in both the Tararua and Ruahine ranges, separated by the Manawatu River, averages about one third of this. Being older than the mountains the Manawatu River kept cutting down as the ranges rose up. Most of this river's flow is sourced from east of the main ranges, proportionally about one-third from Ruahine Range tributaries and two-thirds from Tararua Range tributaries. Generally, weather in the east tends to be dry.


Checking a rain gauge, top of the Ruahine Ranges in winter.

Wind, now exploited by a farm of turbines that signal semaphore from the western Tararuas, is another forceful element in the mix. "Research to date indicates the Tararua site to be amongst the best in the world for windpower generation," announced the chief executive of the local power company when announcing plans for the wind farm in 1993. He was speaking of both strength and continuity of winds. This is a part of the region where tramping huts not uncommonly are anchored down by cables, where trampers themselves, for reasons of personal safety, not uncommonly must crawl along exposed ridges.

MAP 1: THE MANAWATU-WANGANUI REGION



Temperature too, can – for what is essentially a moderate, temperate climate – provide unexpected extremes. The range extends from the life-threatening sub-zero conditions on south-facing Mt Ruapehu's icy Dome to drought conditions of summer on the usually moist plains, sometimes so prolonged they threaten the viability of farming.

Extremes, of course, suggest simply the outer limits of norms. However, there are strong indications that some limits are currently being experienced with greater frequency, possibly as an effect of global warming. Within the model of global warming is the El Nino weather, the name given to the warm current periodically occurring off the coast of Peru. Associated with the spread of warm ocean surface waters from the western Pacific Ocean to South America, the intensity of El Nino is determined by the Southern Oscillation Index (SOI). This is a measure of the difference in sea level atmospheric pressures between Darwin and Tahiti. A negative SOI phase is associated with El Nino events. The opposite is known as La Nina.

During El Nino events westerly winds are even more predominant across the region and little moist air reaches the east coast to fall as rain.

This polarisation of weather sequences has lately meant significant flooding in winter and spring. It has also meant sustained drought to the east, brought on by El Nino, but less known has been recent and still mild drought brought on by La Nina to the west of the region.

The land itself is made up of soils that reflect New Zealand's turbulent geological history. Around Ohakune, for instance, the soils are predominantly of volcanic ash; around Marton and Tokomaru they are made up of loess while the plains are largely alluvial. Away from the mountains and ranges our hill country is of three essential types. To the east it is scrunched by the collision of the Pacific and Australian plates, where it forms highly erodible and jointed mudstone. The central region, less impacted by faulting, is papa country of dramatic steepness. In the southern central region sandy hill country can be easily eroded.

RIVERS AND SAND COUNTRY

Where irrigation demands are heavy, where previous forest cover is now sparse and where centres of population are of a size to make demands on them, drought conditions can impact quickly on the richly varied rivers of the region.

The rivers include the Whanganui, itself fed from not only mountain streams and springs but from the papa-country tributaries to the west, and the shingle-bottomed Rangitikei with its hard Kaimanawa shingles. Both cut spectacularly deep bench terraces from the sedimentary rock. South of the sometimes wild water of the Rangitikei, the tributaries and main stem of the Manawatu hunker on the huge flood plains they have created. Their source is not only the ranges but, because of the Manawatu River's unusual ability to divide the ranges, streams from the east of the main divide. The mud-stone of eastern river catchments provides very little storage of water to maintain river flows between rainfall events. It is, however, itself "stored" in our rivers, being the most important source of "suspended sediment". Typical of the western catchments is the nature of flood flows. These are believed to have become more of a problem since deforestation. The Waimarino, Rangitikei, Manawatu and Horowhenua were, until the swift and almost irreversible changes from the 1860s – fully realised in the 1880-90s – covered in dense and often impenetrable forest.

Some rivers are of such natural significance that five have water conservation orders over significant reaches of them: Rangitikei, Manganui a te ao, Hautapu, Mangatainoka and Makuri. The presence of Blue Duck and trout fishing are important features of these rivers. The Whanganui, with its extraordinary Maori associations and history, lies at the centre of New Zealand's only river national park.

The region's western seaboard of sand dunes and driftwood-strewn shore is, in geological terms, far from being insignificant. Indeed Dr Patrick Hesp, geographer at Massey University, Palmerston North, describes the dunefield that extends from Wanganui to Otaki as the largest in New Zealand and one of the largest in the world. Furthermore, it is a coastline that has extended into the sea at a rate of four kilometres in 6,500 years and continues to do so at this rate of more than half a metre a year. The lakes in this sand country are the result of distinctive geological processes and, where human activities permit, they still provide habitat for a range of unusual, ephemeral plants.

SETTLEMENT

These then were the elements of the land settled perhaps 600 years ago by a number of iwi, including to the north the Whanganui iwi, and their neighbours, Ngati Tuwharetoa. Immediately south of Wanganui are Ngata Apa and Ngati Hauiti and centred on the Manawatu, Ngati Rangitane. Raukawa who came as allies of the invader Te Rauparaha, coexist today with earlier tangata whenua Muaupoko, occupying much of the coastal area between the Rangitikei and Waikanae Rivers. To the east are the tribes that make up Ngati Kahungunu.

Spray irrigation on the Manawatu Plains, high summer.

While it took time for them to find ways to live sustainably with nature, the evidence is that, in large part Maori did. We find this in eel cuts draining lakes to the sea (the only eel cuts formally protected in New Zealand law). We find it in the almost accidentally preserved rare coastal forest remnant of Papaitonga, beside Muaupoko's traditional, fortified islands on large dune lakes, which are also wahi tapu. And we find it in the riches once common along that shore yielded by archaeology and revealed by lingering stands of harakeke.

Looking towards Tongariro National Park from the Kaimanawa Ranges.

It was into these forest cultures, some riverine, some estuarine, that Europeans were attracted. In their milling and their draining they turned, for example, what had been a small clearing into the largely deforested plain now dominated by the city of Palmerston North. Scandinavian migrants were brought initially to the Rangitikei, as one instance, for their logging expertise. It is they who gave the Nordic names of Dannevirke and Norsewood to what is otherwise a string of Maori place names through southern Hawke's Bay. What remained after logging was usually fired. The consequences of this are eloquently recounted in James Wilson's *Early Rangitikei.*

What remains on the plains? Riparian kowhai, still eloquent in spring along the Rangitikei River. A rare stand of kahikatea near forlornly named Rata. Round Bush, on the Foxton Flats, that seems to contain only blackbirds. The scenic preservation stands along the Whanganui and a few die-hard reserves. Long term, all these may not be sufficient even to perpetuate themselves. Particularly when, to add to their beleaguered condition, they are subject to a range of exotic predators. Possums are public enemy number one; rats, stoats, weasels and ferrets are close behind. Other animals of a more domesticated nature, such as dogs and cats, are also a problem. As well, increasing numbers of introduced plants, of which Old Man's Beard is perhaps the most publicised, continue to invade our native forests.

Almost as transforming was the drainage that occurred of the extensive wetlands lying, for example, between Shannon and Foxton. Ecologist Geoff Park recounts that much of this was navigable by canoe. While flax, the most obvious product of the wetlands, was commercially exploited for almost a century, few signs of this industry today are outside of museums. Widespread drainage and development for agriculture meant the decline of the wetlands. With them went huge spawning grounds and nurseries for fish, including marine species and whitebait and eel and loss of habitat for a wide range of insects and birds.

Nevertheless, both the Manawatu and Whanganui river estuaries remain important feeding, breeding, roosting and resting areas for more than 50 species of birds, some international migrants.

AGRICULTURE AND INDUSTRY – INTERNATIONAL PRESSURES

Since colonisation, agriculture has always been at the core of activity and economy in the region, characterising it as quintessentially provincial heartland. Different sectors dominate in each District, reflecting local geography. Pastoralism in Tararua, beef, sheep and cropping in Rangitikei, dairying and cropping in the Manawatu, sheep and beef in Ruapehu and horticulture and dairying in the Horowhenua. But although primary production shapes the face of the region, its character continues to change, subject to the fluctuations of world commodity prices. Dairying continues to increase while sheep numbers still decline.

Agriculture makes an important contribution to the overall economy, providing the raw materials for many of the process-based industries in the region. But even this sector is not immune to change. Continuing rationalisation has forced the closure of the many co-operative dairy factories that previously dotted the region. The result has been that now most milk is no longer even treated here, but at Hawera's behemoth "churn and burn" plant. And the meat industry continues to streamline itself. This often means closure and lost jobs but also reduced pressure on an environment in which their wastes were dumped.

Forestry has been a growth industry throughout the region, with pine forest plantations established particularly in the Ruapehu, Wanganui, Rangitikei and Horowhenua districts, benefiting from the high pulp prices of the mid-1990s.

CITIES

While it is largely farming whose wealth created the cities and infrastructure of the region, today as standards of environmental protection increase, it becomes necessary for us all to keep a closer watch on the environment on which we all depend.

Cities are great users of resources. The populations of greater Wanganui and Palmerston North account for almost half of the 226,000 people living within the region – the fifth largest region by population in New Zealand. Cities and their usually less demanding cousins, the towns, have many and often continuous asks to make upon their immediate environs.

In simple terms these can take the form of resource depletion or pollution of some kind. They range from the obvious, like simply encroaching on good arable land, to the fouling of ground or surface water. It was originally the towns' needs for timber that contributed to the rapid demise of lowland forests. Today these demands are largely met by large plantations of exotic, mainly pine forest, thereby sparing remaining natives.

But cities also make demands that go far beyond their precincts. Their need for power, for instance, can lead to the demand for hydro stations. While hydro electricity has often been described as making no demands upon the environment, this is not necessarily correct. Any Maori eel fisher, watching elvers trying to pass up over high dams, or mature eels on the reverse journey, will confirm this. And the same is true for other fish species, both native and exotic.

Equally, the pollution emanating from a less than sustainable city can have effects far beyond its "walls". An extreme example of this is acid rain. Fortunately, this is not an issue in New Zealand; indeed even air pollution is so insignificant and so actively dispersed that it is not considered a matter inviting concern in the region. However, there are two problems. Locally, air pollution from spray-drift is an issue and, from a global perspective all "greenhouse gases" are considered to be contributing to climate change.


Taihape in autumn.

GROUND AND SURFACE WATER, THE COAST

However, like several other plains districts of New Zealand where significant cities are found together with extensive agricultural and horticultural activities over alluvial gravel, ground water quality has been affected. Ground water provides about 80 percent of drinking water for Wanganui City and all of Foxton's. It contributes significantly to the water supplies of Palmerston North, Feilding and Marton. In brief, the decline in ground water quality is put down to both natural hydrological processes and human activities.

Surface water quality is also affected by agricultural activity, which is heavy throughout the region, and by the activities of cities. If pollution-free swimming opportunities are used as a measure of the health of our rivers, the truth is that swimming below municipal sewage discharges on a number of rivers, is not recommended. Again, encouragingly, since the Wanganui township has recently changed to an ocean outfall, its river quality has already notably improved.

Flax cutters in the Moutoa Swamp, 1912, at the peak of the Foxton flax milling industry. Note the height of the flax and the absence of weeds, such as blackberry. (Palmerston North Public Library)

Other measures of river "fitness" include slime, as an indicator of excessive nutrient build-up, and oxygen levels, an indicator of life-supporting capacity. Both of these show up as measures of stress in summer when water volumes are lower (but industrial and agricultural discharges remain high) and demand for abstraction of the resource is higher.

On top of all this, water temperatures in wide, shallow rivers and streams can rise to what may be unacceptable to both fish and some sensitive invertebrates, such as mayflies.

Rivers in some circumstances can also offer a wide range of measures and indicators of phenomena that can be brought together in one place. The Tamaki River in the eastern Ruahines, is such an example. A short river with large alluvial gravel fans, it was known to flood regularly, cutting deep channels into its banks before sluicing gravel over adjacent farmland. The installation of a concrete weir at a major washout in the channel has meant the river is no longer cutting down, nor producing excess gravel. The gravel banks have been planted up with natives, further adding to stability as well as providing riparian native cover for native fauna, both instream and terrestrial. While climate change may well have assisted this river's recovery, such examples remind us that the individual indicators are really a part of a system that in its natural form knows no divisions.

The region's western coastline is extensive but you seldom see postcards of it. This is not because it is lacking in beauty or admirers, but because it does not conform to norms of what seaside resorts look like. It is a sandy coast, frequently lashed by westerlies with driftwood piled around many river mouths. It contains some of the most significant parabolic dune lands in the world, many today afforested as a conservation-production measure. One hundred and fifty years ago it was girded with a string of dune lakes, among the most outstanding survivors of which are Papaitonga, Horowhenua, Koputara, Paure, Wiritoa and Virginia. Some of these still have considerable significance to tangata whenua, especially for eeling. The dunes have ever been unstable and despite this being a place of spinifex and pingao, such natives were never completely effective in stabilising the historical foredunes.

The region's eastern seaboard is a rocky and therefore more stable coastline. It is also more productive of fish but it would also be fair to say that it is one of New Zealand's lesser-known coastlines.

PESTS

Thus far in this introduction, we have talked mostly about the impacts of human actions on the natural world. However, there are also a growing number of animals and plants brought to this country which impact heavily upon natural ecosystems. The most infamous of these is probably the possum, but rats, ferrets, stoats and cats are equally culpable in their destructiveness. Many domesticated animals, including cattle as we shall see, can also have a profound impact on the environment. Less understood is the phenomenal encroachment of many exotic plants, but Old Man's Beard, one of the country's most destructive introductions, first became identified as a problem in this region a decade ago. Sadly, in many remnant native forests it remains still unchecked. Even more worrying, it is but one of 2000 such plants now free in New Zealand's wild. horizons.mw considers biosecurity to be the biggest challenge to indigenous biodiversity.

Indeed, it is these threats that have over the past 30 years put standing native forests and their precious natural fauna into extreme degradation in the Ruahines, Waitotara and Whanganui regions. While 1080 and trapping can bring a measure of control, long term the only hope of regeneration for these forests lies in some solution based on genetic control. Part of the tragedy is that there is still so much to know about the forests that the consequences of loss, certainly at a micro level, are poorly understood.

Pests also challenge our agricultural productivity. Possums and ferrets are both vectors of bovine tuberculosis, a disease that, left unchecked, would threaten our cattle and deer industries; insects and weeds are major costs to production. Nearly all these pests are exotic, lacking any natural predators or checks in their new homes.

NATURAL HAZARDS

By comparison, natural hazards, which can directly affect humans as well as the natural world, are all too clearly understood. Earthquakes, floods, erosion and slips are all in this category. However, their relative infrequency can lull us into complacency and their sheer magnitude remains beyond our comprehension. The 1880 Manawatu River flood remains the biggest on record – with half as great a flow again as the 1992 flood we still remember caused so much disruption. The catastrophic lahar outflow on Christmas Eve 1953 resulting in the Tangiwai disaster was anticipated in 1859 by a wall of water from melted snow from a sudden heating of the volcano, washing out an upstream bridge. While disasters are beyond the control of human management, mitigation is nearly always an option and in some circumstances we can do much better than that.

ATTITUDES CHANGE

Upper Mangahao hydro-electric power scheme.

In spite of the deterioration of our environment well into the first half of this century, it has to be acknowledged that increasing environmental knowledge has since created a growing consciousness. While natural terrestrial ecosystems on the plains are still at risk it is debatable whether we are still on a downward slope for other aspects of environmental quality. Attitudes have changed over time. For many years our waterways, for example, were seen as convenient and cheap open sewers for disposing of waste. Consequently, at least three streams in the Lower Manawatu were known locally as "Stink Creek". This is now far less acceptable and gross water pollution is now a thing of the past. Less than 45 years ago, the Manawatu River was far more polluted than now. Excerpts from the 1957 Report *Pollution in the Lower Manawatu and Oroua Rivers*[1] show the river's visual conditions underlined the prevalent open-sewer mentality.

Manawatu River above and below the Palmerston North City Council's sewage plant, 1999.

Palmerston North to Whirokino:

"When examined under low flow conditions at Ruahine Street, Palmerston North, the water was clear and the bottom clean and stony. This condition was unaltered as far downstream as Linton Military Camp ... The small backwater into which the Linton Camp outfall discharges was silt covered. Faecal solids floated on the surface of the water. Further sewage solids entered the river from the Mangaone Stream (carrying the Palmerston North City and other wastes), below which the smell of sewage was very noticeable for some distance below the outfall ... Sewage scum was visible on the water surface about half a mile below the stream ...

... the channel carrying the wastes from the Longburn meat works and the Kairanga Dairy Co ... contained roughly equal parts of grey clay, fat and paunch content ... beneath the bridge pieces of fat were seen floating in the water and stranded on the stone embankment. Pieces of sheepskin and mats of wool fibre were caught on sticks and stones. [The water was clear by three miles downstream of Longburn, though some fat particles were seen on the bottom.] (pp 36-37)

High loading in 1956 came from municipal septic tanks, not always kept in good condition, and straight industrial discharges with little or no treatment from the different abattoirs, freezing works and seven dairy companies in the area. The report calculated the total loading on the Lower Manawatu (not including the heavily polluted Oroua River) from these sources alone was equivalent to sewage from a population of 212,000 people (Table 1).

Efforts were made over the years to clean up the river. Water right conditions were tightened in 1964/65 and early 1980s. Reducing the organic waste load reduced the extent of the river zone affected by sewage fungus from approximately 6 km below the Longburn discharge in 1982/83 to 2.5 km when the freezing works met its water right in summer 1983/84.[2]

Since then, extensive rationalisation of the primary processing sector has removed nearly all the discharges contributed from specific sources. With the freezing works closed, the dairy companies first refocused on the Longburn factory. In the last few years, nearly all milk has been transported out of the region to Hawera for treatment. Municipal sewage has been required to be treated to a far higher standard and resource consents will require further upgrading and reduction in discharge in the next few years. Total loading on the same river is now only two-fifths of 43 years ago – 88,170 person equivalents, even though actual population has almost doubled. Sewage fungus is now no longer found in the Lower Manawatu River.

While solely concerned with water quality, the above example shows how historical data can be used to help provide the comparative basis for future environmental indicators. From such material we are able to "take the pulse" of our environment and check as to whether it is improving or deteriorating.

[1] *Pollution in the Lower Manawatu & Oroua Rivers.* A report prepared for the Pollution Advisory Council by the Ministry of Works in Co-operation with Health & Marine Departments & DSIR, 1957.

[2] J M Quinn (1986) *Manawatu River Water Quality: The Problems and Possible Solutions,* Water Quality Centre, MoWD, Hamilton.

TABLE 1: CHANGING FACE OF THE MANAWATU

BOD population equivalent (300 mg/l) (54 g/day)	*1956*		*1998*
PALMERSTON NORTH CITY Septic tank • (35,500 inhabitants) • Palmerston North abattoir (fat, paunch contents) • Canterbury By-Products Casing factory (pieces of intestines, salty effluent) • Clausens' Plating Works (acid and caustic drippings, chromic acid, nickel salts and cyanides – all dilute) • Ice-cream factories (several) • Breweries (two) • Milk Treatment Station (washing and condenser water) • Jacquard Hosiery Mills (dyes)	45,500	Sewage system (74,000 inhabitants)	46,300
Foxton Borough septic tank discharging to the Loop	(2,526)	STP	980
Linton Military Camp septic tank	(740)	STP	550
Massey Agricultural College and DSIR grasslands septic tanks discharging to Tiritea Stream	(400)	(PNCC sewer)	
Industries and farms			
Gasworks	100 gallons daily ammonia water	Closed	
Aokautere Dairy Factory	100 gallons whey daily, 1300 equivalent	Kiwi Co-op, Longburn	
Glaxo Dairy Factory – Bunnythorpe	Discharge to land but overloaded	Closed	
Railway yard, Palmerston North	Steam engine steam washings and soil store sump wastes and stormwater to drain into Mangaone Stream		
Kairanga Co-op Dairy, Longburn • 8-9,000 gallons casein whey • 20-30,000 gallons floor and can washings • 3,500 population equivalent	Kiwi Co-op Dairies, Longburn		36,600
Longburn Freezing Works	146,000 population equivalent	Manawatu Food & Technology	930
Awahuri Dairy Co	3,500 population equivalent		
Tokomaru Dairy Co	3,000		
Shannon Co-op Dairy Co Ltd	3,800	Richmond fellmongery	960
Foxton Flax Stripping Mill	1,800	NZ Pharmaceuticals	1,850
Total loading equivalent	212,000 people		88,170 people

Major biological oxygen demand (BOD) of discharges to the Lower Manawatu River (excluding Oroua River) in 1956 and now. BOD loads are given as human sewage equivalents. While indicative, this table shows the decreasing load on the river despite an increasing population. It also underlines the changing nature of industry in the Region over the last 40 years.

MAKING CHOICES – FOR SUSTAINABLE MANAGEMENT

Economic conditions necessary for our region's wealth and prosperity continue to be based on our physical and natural resources. Their use has always involved trade-offs. At its starkest these are between a living museum piece of preserved and reconstructed Gondwana, missing only the moas; or a vast primary production factory to the world. Neither extreme has a place for people and we are seeing a widening acceptance of a middle path of the sustainable management ethos as contained in the Resource Management Act, whereby we recognise our place and role within our environment.

A challenge for all of us in making this transition is to have the necessary information to guide our resource use decisions, enabling sustainable management. Information helping us to recognise our past and the consequences of our actions provides a context for these decisions.

Individual resource users demonstrate a strong understanding and recognition of sustainability at the individual scale over the short to medium term. The "Bridge to Nowhere" crossing the Mangapurua tributary on the mid Whanganui River starkly reminds us that for many pioneers, hard work and dreams were not enough to overcome the land's limitations. But environmental impacts from resource use can be more insidious, creeping up on us over the decades and generations. Lacking a collective memory we gradually forget what was once ours. Only a venerable kuia remembers the cobbles covering the bed in the lower Whanganui River where now there is only mud from upriver erosion. But other pressures on our environment, brought about by the small and incremental actions of many over time, are more noticeable. The build-up of nitrates from agriculture in the Horowhenua, the high demand for water from the Oroua River, are some of the more obvious examples.

However the region has never taken comprehensive stock of the situation before. This reflects in the past the absence of any comprehensive resource management responsibility at a regional scale, so that data collection systems where present, focused on particular activities. So while we have good data on water quantity stretching over a long time span carried out by the former Catchment Boards, for example, we are less able to assess the consequences of over a century of land use. This State of the Environment Report is therefore the first time anyone has tried to take the regional pulse. It is not as comprehensive as we would like, nor is it complete in its chosen coverage. Simply, many of the data collection systems are only now being put in place and for other systems we still do not have sufficient data to draw any interpretation. Where data and information are lacking we have used case studies as a first step to highlight issues. However this initial report does identify many of the gradual and widespread changes occurring within our region. These provide a context to set future direction for both the region's resource users and for horizons.mw. They set an expectation for the future.

In many ways, this is an ideal region in which to demonstrate the importance of environmental indicators. This is because few places better than Manawatu-Wanganui show the mutuality of interest between sustainability for farmers and for nature. Both the hill country and the sand country have been so affected that neither natural ecosystems nor farming can recover without the assistance of the other.

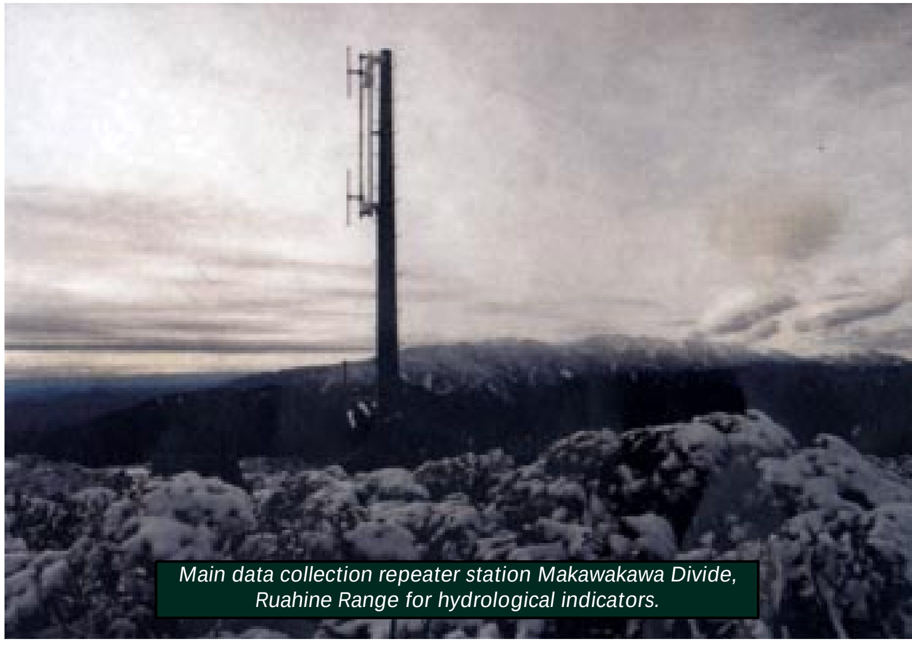
INDICATORS – WHAT ARE THEY AND HOW DO THEY WORK?

horizons.mw has developed a Regional Monitoring Strategy (RMS) establishing a comprehensive environmental data gathering and information system for the Region. It is designed to:

- assess the effectiveness of its resource management policy
- assist regulatory action; and
- provide an "early warning" for future policy development.

The strategy identifies resource management issues, and indicators to monitor progress towards addressing them. The data collected will identify trends, though not necessarily their causes. Where little information exists, monitoring will provide a benchmark for establishing trends in the future. It does not provide information to solve specific resource management problems. Rather, it identifies where specific research is needed to understand why we are observing particular effects.

The State of the Environment Report is one of several reports prepared providing results of horizons.mw monitoring activities. It is intended to be prepared every three years, reporting on the region's environmental quality, primarily in regard to horizons.mw's Section 30 functions of the Resource Management Act.


Main data collection repeater station Makawakawa Divide, Ruahine Range for hydrological indicators.

The RMS has been developed using the Pressure-State-Response Model (PSR). The PSR model has three types of indicators, each identifying environmental quality from a different perspective:

- Pressure: on the environment from human activity (directly or indirectly)
- State: describing environmental conditions resulting from human activities
- Response: organised behaviour to reduce, prevent or mitigate undesirable changes.

Pressure indicators are used to predict future environmental issues that may require a policy response; or alternatively, where policy may need modification to meet new demands.

State indicators summarise past actions. They can show effectiveness, in the short term, of policies and resource use activities. They can be used for initiating enforcement action, and possible consequent policy development.

Response indicators can demonstrate the regional community's response to horizons.mw policies and actions. They give some measure of the importance to which the community regards the issue.


Contract road builders, Scotts Road, Linton, 1910. (Palmerston North Public Library)

In each case, clear cause and effect relationships may not be easily discernible, given the range of influences on resource users and the difficulty of obtaining clear results. The Regional Monitoring Strategy contains an interlocking series of indicators. Individually these indicators provide a simple look at the environment; collectively they seek to provide a comprehensive and integrated overview of environmental quality in the region.

The PSR model is not ideal and sometimes is ill-fitting for identifying the issues in our region. However, it does provide a good framework for organising environmental parameters, and so is used where suitable in this report. It is also being used increasingly worldwide, including the New Zealand National State of the Environment Reporting programme run by the Ministry for the Environment.

Our choice of indicators has been pragmatic – we want to monitor resource management issues facing the Manawatu-Wanganui Region. Monitoring needs to be cost effective, using indicators that are both relevant, informative and within our capability to support. Some or our indicators are basic, serving as early warning signals to initiate further research and monitoring should they be triggered.

We should note that, since the programme is only in its infancy, it is far from being comprehensive or complete. And that the more you, the people of this region, are able to contribute knowledge, observation and ideas to it, the better the indicators will enable us all to create a better environment for all concerned in the future.

HOW DO COMMUNITY/IWI CONTRIBUTE OR RESPOND?

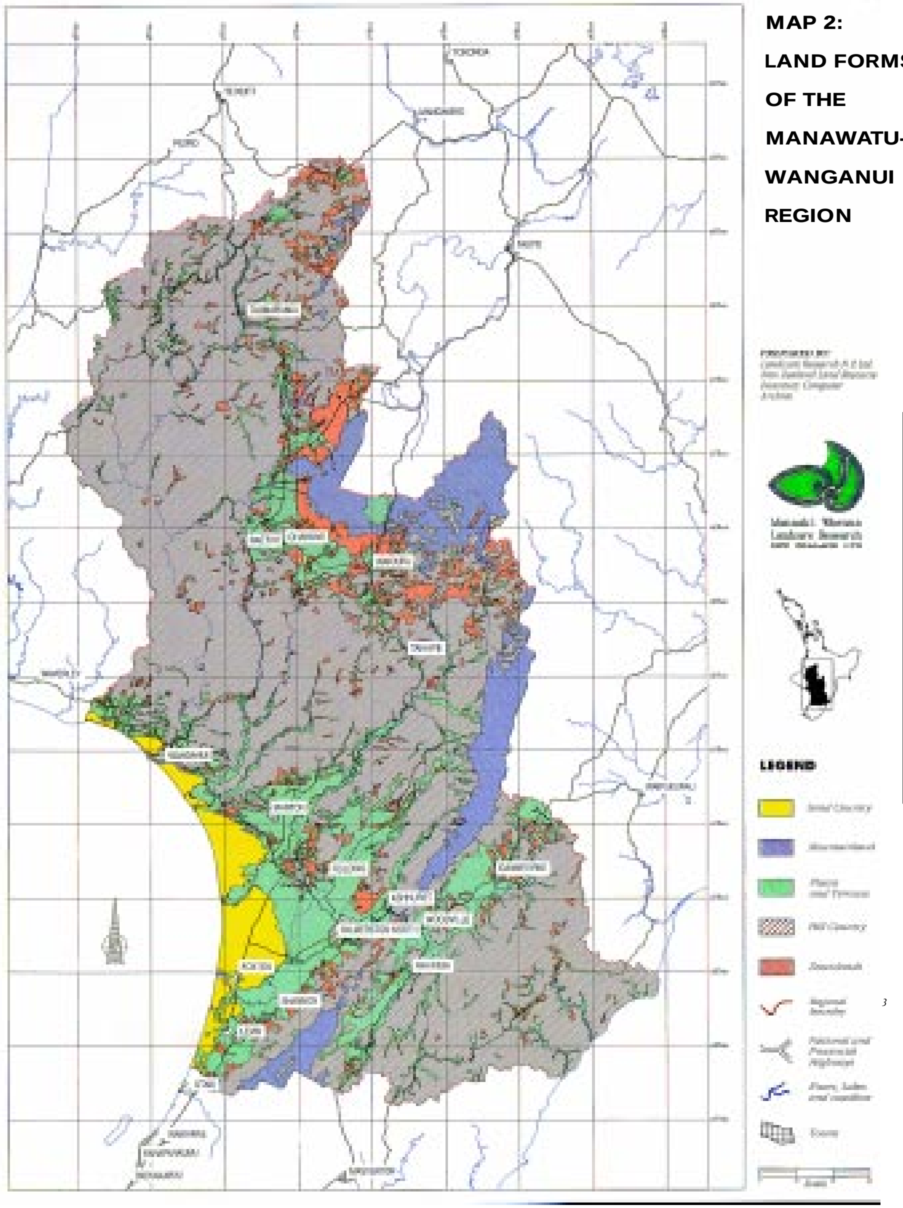
The tangata whenua, by definition, are the original Kaitiaki (guardians) of these lands. Their role and their customary rights are protected under the Treaty of Waitangi. Under the Resource Management Act Maori need to be consulted and involved in resource management issues and processes.

In many cases, continuing Maori involvement in such traditional activities as eeling, whitebaiting and gathering of tuatua could mean that, with their agreement, important historical and contemporary knowledge about these organisms as environmental indicators could be collected. In a small but significant beginning, tangata whenua have become involved in monitoring of water quality on the upper Whanganui. Subject to their agreement, tangata whenua could become much more closely involved in an on-going way in the entire process.

Similarly, apart from the obvious interest of local environmental and community groups, many who recreate in the coastal, mountain or river environments of our region will have their favourite activities and places. Sometimes the knowledge will be general, sometimes specific, but over time, it will be about changes – for the better and the worse – in our regional environment. It is this awareness that the indicators programme aims to enhance and systematise. When large numbers of our citizens become aware of their environment, large numbers will also care about it. Since the task of protecting and enhancing our region is far beyond the resources of horizons.mw, we need as many hands "to the pumps" as we can find. Our environment is everyone's responsibility.

PART I

THE LAND – EROSION, ECOLOGY, PESTS, NATURAL HAZARDS



MAP 2: LAND FORMS OF THE MANAWATU-WANGANUI REGION

The region is large and its land resources are diverse in nature, capability and environmental vulnerability. Land management issues are therefore important in the region. While its land resources support a range of economic activities, agriculture predominates. There are also significant areas of Crown land, including Conservation estate and Defence land, and production forestry. Some 12 percent of the region's land (276,892 ha) lies within the Department of Conservation estate, managed by the five conservancies that lie partly within the region.

Our land faces some common themes, including erosion, ecology and hazards. But specific issues within vary within the region. Accordingly, we have divided up the region based on soil types, each of which has its own set of special management issues and means to monitor them.

Soils in the region are grouped into five landform suites[3] of distinct landform types based on the New Zealand Land Resource Inventory (Table 2). These are shown on Map 1. Each has its own unique set of resource management issues.

TABLE 2: MANAWATU-WANGANUI REGION – LAND FORM SUITE AREAS

Land Form Suites	*Area (ha)*	*Percentage*
Sand country	79,313	3.6%
Plains and terraces	386,239	17.4%
Downlands	191,861	8.7%
Hill country	1,358,226	61.3%
Mountainland	183,364	8.3%
Total Manawatu-Wanganui region	2,199,003 *	

** This does not include 17,226 ha (0.7 percent) covered by lakes, towns or cities.*

The region has substantial areas of highly productive alluvial plains and terraces, particularly in the Manawatu Catchment. This is vital to the farming economy of the region. Class I and II land, as classified in the Land

3 **Sand country**: *Formed from windblown sands. Contains four subtypes: Foredune areas; Dune Systems with a high erosion potential; Dune systems which are relatively stable; and Sand plains.*
Plains and terraces: *Land with slopes less than 3°; most versatile and productive land. Two significant subtypes; Taupo pumice formation sediments (2 percent); and all other lithologies: greywacke sand and siltstone.*
Downland: *Rolling to strong rolling slopes (less than 15°). Range of soil types which supports a range of pastoral activities including highly productive cropping industry. Two subtypes: Taupo pumice formation sediments (50 percent); and all other lithologies.*
Hill country: *Land generally with a slope greater than 15°, not suitable for cropping, and does not comprise sand dunes or mountainlands. Four major subtypes based on rock type: Taupo pumice formation (or older) (50 percent); Soft sandstone; Greywacke; and all other rock types.*
Mountainland: *The Tararua-Ruahine, Kaimanawatu and Hauhungaroa Ranges and the higher slopes of the Tongariro National Park.*

Resource inventory, is the best and most versatile land. It is a subset of the plains and terraces suite. It is particularly significant because of the potential conflict in land use between high value agricultural production, and urban expansion on the edge of towns and cities.

Many soils in the region are vulnerable. More than two-thirds is hill or mountain country. Hill country includes volcanic and tertiary soil types of mudstone, sandstone, siltstone and greywacke. Of these four major types only the greywacke is stable (3.2 percent of the region). The remainder, covering over 50 percent of the region, is vulnerable and can erode badly. Most of this hill country land has been cleared of its natural cover and is developed for farming or forestry, although some areas have never been cleared and remain in an unmodified state. Generally, hill country is best suited to extensive agriculture or forestry, or for nature conservation purposes such as forest parks, national parks or reserves.

Mountain land generally has high potential for erosion and is vulnerable to mismanagement. Large parts of these lands remain in their natural state. Most of this land is in National Parks, Forest Parks and Defence areas. Large areas of this land have also been reserved in some way and managed by the Department of Conservation. Thus a considerable degree of protection has been provided.

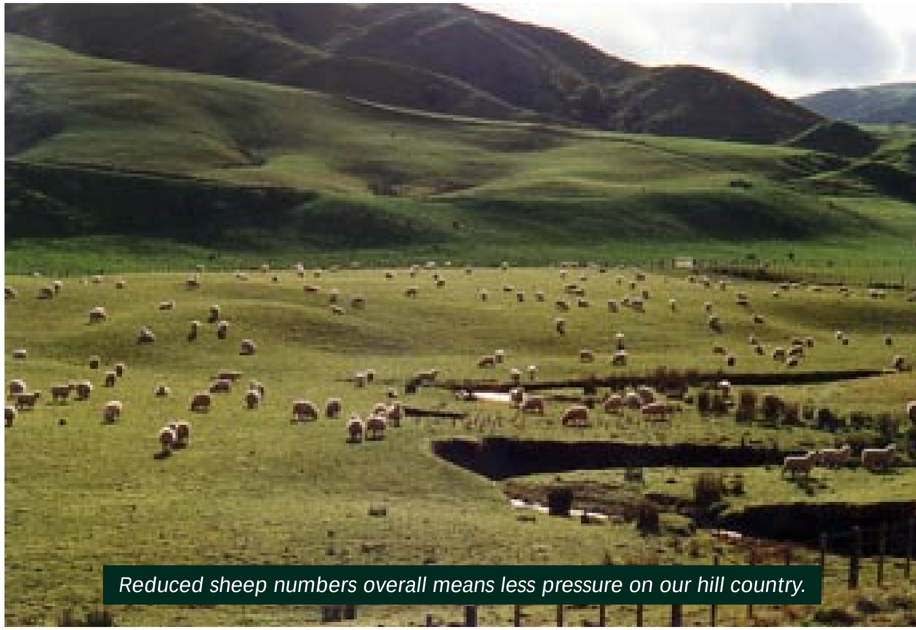
Much of the sand country is fragile, particularly the coastal and foredune area of the west coast, placing severe limitations on its use. This is only a small part of the Region (0.1 percent), but areas of unstable dune systems are highly prone to erosion if vegetation is displaced. Note sand country erosion is addressed in Part III.

SOILS

SCARS ON THE LAND: SOIL EROSION IN HILL COUNTRY

Soil is the living mantle that develops over time through biological and weather forces acting upon the top layer of parent rock. Natural erosion is part and parcel of the landscape in a geologically new country like New Zealand.

If, however, we look first to the hills, immediately we see another problem of erosion. The slip scars are evident to anyone travelling the main highways of the region – a sure and desperate signal. Until the last hundred or so years, the hill country in Manawatu-Wanganui was almost completely clothed in a dense temperate rainforest, with a rich humus layer and topsoil based on organic matter. However, this is a soil produced and sustained entirely by the ecosystems of our native forests. With three quarters – much more on the lowlands – of forest cleared for pasture, these forest soils have been washing down into our steams and rivers.


Reduced sheep numbers overall means less pressure on our hill country.

Once the roots of the forests rotted away, the exposed hills began to slip. Our pastoral hill soils are now perhaps two thirds of the way through a 're-balancing'. This is a dramatic phase of adjustment to not having trees. Our hill soils will continue to become shallower until they reach a depth that is stable under pasture. At the same time gully erosion has intensified, resulting in renewed down-cutting of small gullies and streams. This sets off more slip and earthflow erosion.

The combination of accelerated slip, earthflow and gully erosion has resulted in drastic and profound changes downstream. Away from the hard rock of the main ranges, our river and stream beds are now mostly filled-in with silt and sand where previously gravel was more evident. These changes have vastly altered the ecology of our hill country waterways in "soft-rock"

SOIL EROSION INDICATORS

- **PRESSURE**: the percentage of unstable hill country without 'protective vegetation'
- **STATE**: the soil turnover in the hill country, percentage of fresh and healing over slip scars
- **RESPONSE**: what is being done to address the erosion issue, effectiveness of the response.

rivers like the Ohura and Whanganui, reducing the diversity and abundance of aquatic flora and fauna, especially fish. The silt and sand in these upstream parts of rivers and streams will take decades to move through our river systems – creating a continuing source of muddy water.

Summarising, soil erosion causes economic and ecological impacts:

- **loss of soil on the hills**. It takes about 40 years for topsoil to re-establish on slip scars and the soil generally only returns to about 80 percent of its original productivity. There are also problems with loss of the topsoil ecosystems. Lower down inundated pasture can take a year to return to full productivity
- **damage to farm structures**: fences, tracks, buildings

TABLE 3: EFFECTIVENESS OF TREES IN REDUCING EROSION

Technique	*Effect (% reduction in erosion compared with pasture)*
Sparse space-planted trees (> 12 m apart)	10%
Dense space-planted trees (< 12 m apart)	60%
Mature plantation trees, close canopy scrub or indigenous forest	90%

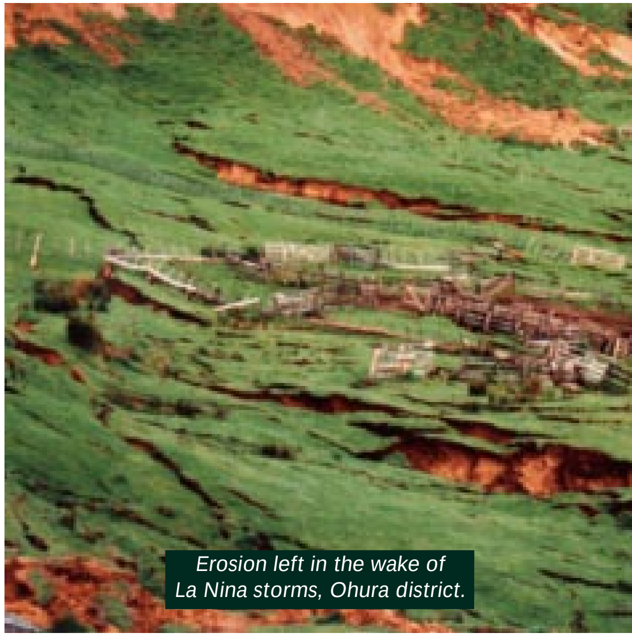
- **silt into waterways** causes problems for fish, invertebrates and most things living in water.

Soil conservation recognises that appropriate vegetation cover is the key to preventing accelerated erosion. For example, research following extensive erosion events (Hicks *et al*, 1993) has shown that tree planting is an effective way of preventing erosion (Table 3). This gives us a key for measuring on-site soil loss.

To collect our pressure and state indicator data we use aerial photos. Forty-five sites were randomly chosen in hill country. Each site, 2.75 km by 2.75 km, was aerially photographed. Overflight photos were taken between 1995 and 1999. They were analysed under a stereoscope to determine the landform, vegetation cover and surface stability at 36 points on a 2 cm grid on each photo.

HILL COUNTRY UNDER PROTECTIVE VEGETATION (pressure)

Erosion is not uniformly spread through the hill country, but occurs in certain landforms. It is useful to target erosion control efforts to the most erodible landforms and sites. Also, different vegetation types are needed, depending upon the landform.


Erosion left in the wake of La Nina storms, Ohura district.

About a third of the hill country consists of terraces, downlands and ridges (shown as green landforms, Figure 1). A dense pasture sward is all that is required on this land to protect it against sheet erosion, the main erosion form on those landforms.

Hill slopes, gullies and stream banks comprise about two thirds of the hill country (orange landforms). Hills are susceptible to slips and earthflows. Trees are required, at a spacing of 12 metres apart or closer, on hill slopes, gullies and stream banks to protect against mass-movement erosion (slips and earthflows) and gully and stream bank erosion. It makes little difference whether trees are native or exotic plantations.

Figure 2 shows the percentage of each landform with vegetation that is 'protective' against the main erosion processes on that landform. These vegetation types do not prevent erosion, but they do reduce it to natural levels, similar to what would have been expected under the former native forest cover.

Overall, 60 percent of the hill country has protective vegetation that reduces erosion to near-natural levels. This leaves about 500,000 hectares of hill country at risk to accelerated erosion. Most of this is in hill slopes, gullies and stream banks. Hill slopes are 45 percent covered in trees, gullies are half covered, and stream banks are about half covered. By comparison, ridges, downlands and terraces are over 95 percent covered in dense pasture.

SLIP SCARS (state)

Some 65 percent of the hill country is unstable and 14 percent of the hill country has fresh or re-vegetating scars (Figure 3).

Most of total erosion in hill country occurs on hill slopes. However stream and gully landforms have a relatively higher impact because of their additional off-site effects on water Although stream banks and gullies comprise only 11 percent of the hill country, one third of fresh and revegetating scars are found on stream banks and gullies, with erosion debris being washed directly into streams. Some erosion debris would also be entering streams from hill slopes, confirming results from Tutira and Gisborne (Trustrum, unpublished) where about half of the mass movement erosion ended up in waterways.

PLANTING (response)

Through horizons.mw's Environmental Grant Fund horizons.mw and farmers together contribute around $700,000 per year to erosion control projects in hill country. This is expected to protect about 1200 hectares of land per year, or 0.2 percent of the erodible hill country where tree planting measures are recommended. In addition to this work, a few thousand hectares of commercial forest is planted per year without grant assistance.

The area of soil conservation space-planted trees and exotic forestry indicates the size of the response to the erosion issue. Seven percent of the unstable hill country has been either afforested or space planted. This includes 3 percent of the unstable hill country (around 25,000 ha) afforested in the last five or so years.

FIGURE 1: Landform distribution in hill country (after Crippen, 1999)

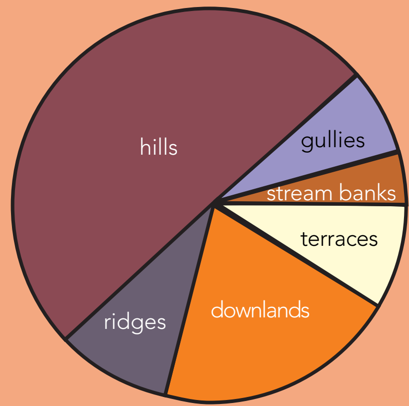


FIGURE 2: Percentage of hill country with protective vegetation by landform (adapted from interim data from Crippen, 1999)

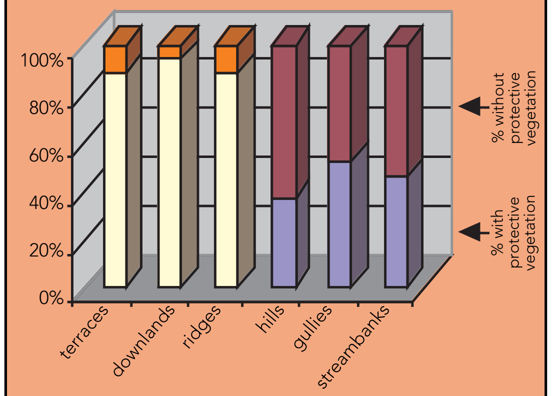
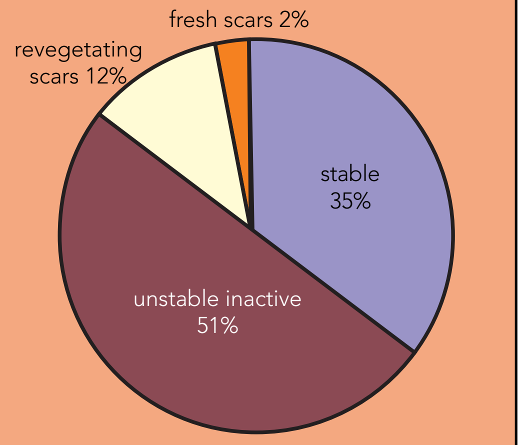


FIGURE 3: Erosion location in hill country



SUMMARY

Where implemented, soil conservation efforts by the community are having a positive effect in reducing erosion, but these efforts remain small by comparison with the total hill country erosion problem. If the afforestation rates demonstrated over the last five years continue, it will take around 100 years to protect the region's unstable hill country land.

References

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Westview case study

In 1995 a study was commenced to look at whether sustainable management was being attained on the "Westview" property of Shane Carroll and Nicola Shadbolt in the Pohangina Valley, some 30 kilometres north of Palmerston North. Westview was a very interesting property as it included many land types, varying from very good quality soils on the flats right up to very steep and climatically challenged areas high on the west face of the Ruahine Range. The property is stocked with deer, sheep and cattle, with some areas in exotic plantings and others in cutover native scrub and bush.

The study was undertaken collaboratively by scientists at Agresearch and Landcare, and was jointly funded by the Public Good Science Fund, Meat Research Development Council, horizons.mw and the Ministry of Agriculture. A community group was formed including representatives of the farming community, along with other interested parties, to look at management issues on the property. The community group considered all aspects of sustainability, including the long term environmental sustainability of the property, its economic viability, and the social continuity of the community within which the farm exists.

The overall findings of the study were most encouraging. The land was able to be used sustainably, while at the same time supporting an economic farming unit. Detailed studies of soil types in particular have enabled Shane and Nicola to "fine tune" the management of different parts of the property to improve environmental outcomes while optimising economic returns. For example, areas have been identified that cannot carry cattle in winter because of potential pugging and treading damage. Essentially, the owners now look at their farm as a number of individual land units, each of which requires different management to perform at its optimum.

Studies such as this at Westview indicate that with sympathetic management much of the hill country of our region should be able to be farmed sustainably. What we do not know for certain however is how widespread such practices are, and how on particularly vulnerable soils, such as unconsolidated sandstones, sustainable management can be achieved within a pastoral farming environment.

PLAINS, TERRACES AND DOWNLANDS

The main issues on these landforms are soil loss and degradation resulting from land being used beyond its capacity for sustained production. Loss can be from surface run-off on cropping land and wind erosion, and soil compaction and pugging.

DOWNLANDS

Case Study 1 – Hosing off more than the carrots: Soil erosion on Ohakune-Raetihi cropland (state)

In recent years, recreational fishers have become increasingly concerned about the effects of the carrot industry on the Mangawhero River, a valuable trout-fishing river. The Mangawhero drains from Ruapehu through the Ohakune-Raetihi downlands and Parapara hill country, into the Whangaehu River.

The main source of sediment to this usually clear river was thought to be discharges from carrot washing facilities. Anecdotal evidence also points to erosion from carrot and potato paddocks as a significant sediment source.

An unfinished study by Landcare Research with support from horizons.mw on a 'worst case' paddock with anecdotal evidence of severe surface erosion has produced some surprising interim results. It found that up to half a metre of soil had been lost from eroding fields. The preliminary data, taken from the steepest part of the paddock, suggested a net loss of about 200 mm of soil in the last 16 years, more than one centimetre per year. This figure is comparable with erosion rates from Pukekohe cropland. Compared with erosion rates from other landforms in the region, the Ohakune 'worst case' paddock is:

- eroding 10 times faster than the 'worst case' wind erosion paddocks on the Manawatu Plains; and
- eroding five times faster than hill country in inland Taranaki, where intensive monitoring has been done.

We do not expect to find erosion as bad as this on other Ohakune cropland. More work is required to discover overall erosion rates from typical cropped paddocks in the Raetihi-Ohakune area. Presumably, one reason why the erosion rate is so high is that much of the soil was removed by washing from the "produce". We need to know too the effect of management practices on erosion. It is unclear how much of the soil lost could end up in waterways and how much in carrot wash settling ponds.

The amount of soil being discharged into the Mangawhero from carrot washing has been steadily decreasing since the 1930s.


Loss of soil from land use practices.

Reference

Basher L.R., Ross C.W. and Dando J. (1999) *Surface erosion in the Ohakune area: A progress report*, contract report by Landcare Research for Manawatu-Wanganui Regional Council.

TERRACES

Case Study 2: Blowing ill Wind Erosion on the Manawatu Plains (state)

Wind erosion from cropping land is a major resource management issue on the Canterbury Plains, but until now has not been recognised as an issue for Manawatu cropland.

A recent case study by Landcare Research targeting sites where wind erosion was most likely to be found has shown soil losses of up to 1 mm a year from conventionally cropped soils (Table 4).

More work is required to deter-

PLAINS, TERRACES, DOWNLANDS INDICATORS

- **PRESSURE**: Area of cropping (not reported)
- **STATE**: Soil loss from wind erosion Soil compaction

mine whether wind erosion is an issue on the Manawatu Plains, and if so, how widespread it is.

Some of the questions that need to be answered are:

- What effect has the erosion had on soil productivity?
- What erosion rates can be expected for a typical long-term cropped paddock on the above soil types?
- How applicable are the results to other soil types?
- What effect do the various management practices have on wind erosion, eg.
  - years in crop
  - type of crop
  - cultivation method
  - use of no-tillage cultivation
  - use of crop rotation soil?

Soil compaction from trampling herds can have economic as well as ecological consequences.

TABLE 4: SOIL LOSS FROM MANAWATU CROPLAND
(adapted from Basher *et al*, 1999)

Site	Soil Type	Cropping History	Average Soil Lost	Soil lost (mm/year cropped)
1	Manawatu silt loam	16 years in maize	1.7 cm	1.1 mm
2	Kairanga silty clay loam	23 years in barley then three years in maize	2.3 cm	0.9 mm
3	Kairanga silty clay loam	11 years in maize	1.2 cm	1.1 mm

DOING IT HARD: SOIL COMPACTION AND STRUCTURE DETERIORATION (state)

Soil structure deterioration is caused by excessive or repeated cultivation. Soils with poor structure are more susceptible to both erosion and compaction.

The main causes of soil compaction are cattle treading and agricultural machinery squashing the aerated soil pores in moist conditions. Compacted soils are more susceptible to waterlogging and runoff, less well aerated and more difficult to cultivate. They are therefore less able to provide good growing conditions for plants, and also more likely to leach nutrients or pollutants to waterways and ground water.

All farmed land in the region is to some extent susceptible to soil compaction. Of the 17 percent of arable land in the region that is able to be cultivated:

- 64 percent (240,000 hectares) is highly susceptible to severe compaction under poor management
- 22 percent is moderately susceptible to compaction
- 14 percent has a low susceptibility to compaction.

Other research has identified soil compaction as an issue on dairy farms and hill country sheep and beef farms.

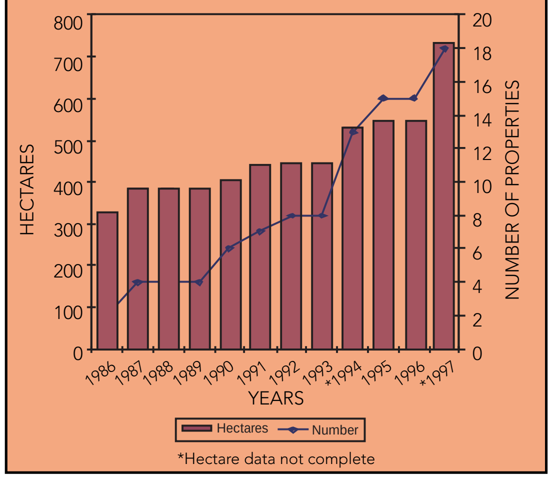
A survey of cropping farmers found that most considered soil compaction a significant issue. They would pay $50 to $100/ha less for a farm with soil compaction. They thought that farmers were responsible for the management of this problem and that more education was needed. Significantly, most said that compaction was not an issue on *their* farms. The annual cost to the region from reduced profits from crop land (not including multiplier effects) is estimated at $6 million.

Unlike the testing of soil nutrients, soil compaction is not routinely monitored by farmers. Were it easier for farmers to assess the physical health of soil, they would develop a better understanding of the effects of soil degradation on their profits, becoming more motivated to prevent such degradation. horizons.mw has therefore contracted Landcare Research to develop a soil health self-monitoring kit for farmers. This will also assist horizons.mw to better understand the overall extent of soil structure deterioration, soil compaction and soil organic matter decline.

A GROWING ALTERNATIVE: ORGANIC FARMING (response)

One approach to land use that is based on principles of sustainable cropping, pastoral and horticultural production is organic farming, which is growing in New Zealand. Its growth is based on recognition of market opportunities, both domestic and international, for a distinctive and desirable product. Related to this is distinctive a philosophy of land use. Growth in organic farming is also a feature in our region (Figure 4).

FIGURE 4: Growth in BIO-GROW certified organic farms in the Manawatu-Wanganui region



Both DEMETER and BIO-GROW, the two international organisations for registration of organic farming set standards to ensure that:

- natural processes or nutrient cycling are sustained
- soil structure is maintained through regular input of organic matter, which supports earthworm populations
- biodiversity of habitats, species and crop species provenances is used as a tool of pro-active land management
- a wide variety of biological means are employed to control pest problems.

There are a total of 259 BIO-GRO and 46 DEMETER Certified Organic Farms within the whole of New Zealand, of which 19 (6.2 percent) are located within the Manawatu-Wanganui Region (as at 30 November 1997). Most certified BIO-GRO properties are within the Bay of Plenty and Canterbury Regions.

Within the Manawatu-Wanganui Region, 18 farms are certified BIO-GRO and one certified DEMETER, covering in total an area of over 840 hectares. The properties are located in the southern half of the region in the Wanganui, Rangitikei, Manawatu, Palmerston North, Horowhenua and Tararua districts.

Since 1986 the predominant and most established land use by far for organics is pastoral farming. Ten properties graze sheep or cattle on land ranging in size from 2.5 hectares to 192 hectares, with the total land utilised being 740 hectares. Most properties are about 30 hectares in size, though farms of over 100 hectares are established in each of the districts. Total land in cropping is 51.5 hectares, the main crop being wheat.

Land in horticulture comprises 40.6 hectares, the main produce is squash, peas, sweet corn and carrots. There are 9.2 hectares of organic orchards. A number of farms have a widely-mixed range of productive purposes.

Although a very small part of current agricultural practice, the presence and growth of organic farming reflects a response to perceived environmental pressures and states, both by farmers and their customers. Interestingly, Heinz-Watties has been quoted in local newspapers as seeking greater volumes of organically grown vegetables to meet its export demands. Accordingly, organic farming may become a bell-wether monitoring module which will be particularly interesting to track over the coming years.

RINGING THE CHANGES: LAND-USE CHANGES IN THE REGION (pressure)

We wanted to track changing land-use and activities in the region to identify incipient pressures on the environment. We wanted to explore changes in cropping, horticulture and dairying, in particular.

Unfortunately, we have discovered that Statistics New Zealand data, upon which we were to base this module on, are of poor quality, with gaps and uncertainties. Accordingly, we are not reporting on this module now, and will explore alternative data sources for the future.

SUMMARY

Our case studies point to widespread problems from soil compaction on all farmed land, localised problems of soil loss from Ohakune cropland, and potential problems from wind erosion on all our alluvial plains. Comprehensive monitoring is programmed over the next few years to better determine the extent of these problems.

REFERENCES

Basher L.R., Burgham S.J., Shepherd T.G. and Webb T.H. (1999) "Assessment of wind erosion rates on the Canterbury and Manawatu Plains, New Zealand, using Caesium-137". Landcare Research. (unpublished).

ECOSYSTEMS

The resilience of our native and production ecosystems is a matter of concern. Their ability to sustain themselves and to cope with stress factors, is what will ensure their long-term health and survival.

The two ecosystem issues are:

- degradation or loss of indigenous habitats, species and genetic diversity, primarily on indigenous biodiversity
- degradation or loss of productive capacity of the soil-vegetation system, reducing its ability to support sustainable production for future generations.

DEGRADATION OR LOSS OF INDIGENOUS HABITATS, SPECIES AND GENETIC DIVERSITY

There are many ways in which we can measure ecosystem resilience, some of which are currently being developed by the Ministry for the Environment.

NATIVE TIMBER HARVEST (pressure)

Logging native timber can lead to the degradation of native biodiversity. Although the obvious concern is that logging exceeds the forest's ability to regenerate, this concern should be alleviated by sustainable logging regimes required by the Forests Act. However, there is concern logging of native timber can reduce the buffer effect to important native habitats, the thinning of native corridors and further reduction of nesting space, food and seed resources. Additional pressures can also be put on the viability of small and isolated native plant and animal populations.

Sustainable native forest management permits and plans are granted by the Ministry of Forestry, under the 1993 amendment to the Forests Act. Sustainable forest management plans are valid for at least 50 years, permits and personal use applications are valid for 10 years. Stringent requirements, based on natural regeneration cycles of individual species, are applied to ensure that the operations are sustainable. Tracking the number of permits and sustainable plans therefore provides an indication of pressure on our native forests.

Habitat in decline, Waihioki Stream, Tararuas.

REGIONAL OVERVIEW

The total volume of native timber approved for harvesting within the region is 7255 m^3. Native timber harvesting has been approved in six of the eight districts in the region. No harvesting is approved in Palmerston North City or Horowhenua District. The greatest volume of native timber harvesting is undertaken in the Ruapehu District where 31 permits, plans or applications have been approved allowing 4093 m^3 to be harvested (56 percent of the total harvest volume). Stratford, a part district of the Manawatu-Wanganui Region has the second largest harvest volume of 1500 m^3 (21 percent).

One sustainable forest management plan has been issued allowing an annual harvest volume of 572 m^3. The plan, in the Ruapehu District, covers a 395-hectare area.

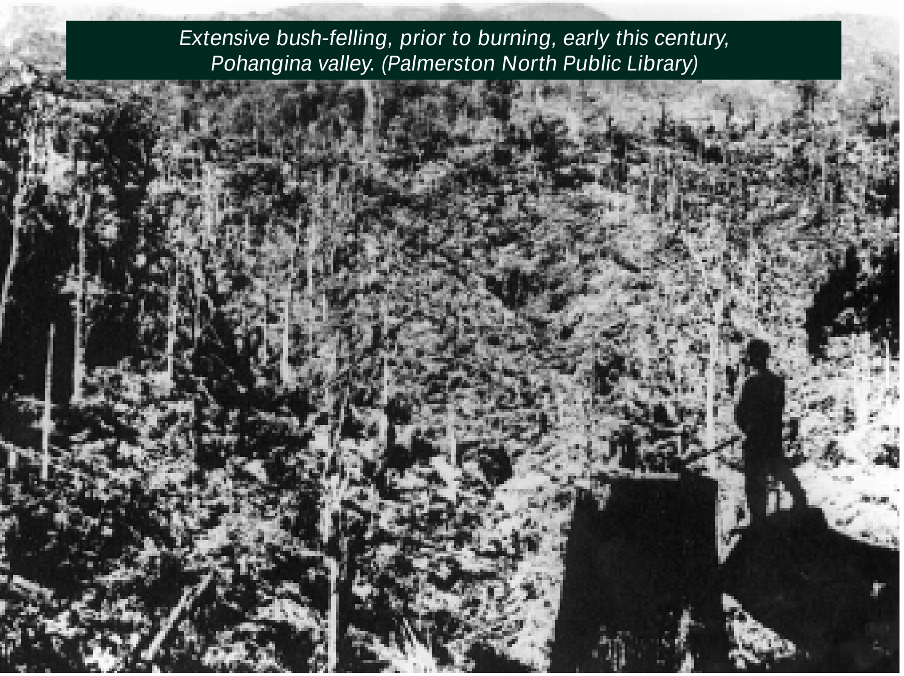
Twenty-one sustainable forest management permits have been issued. The permits apply to a total of 2918 hectares. The maximum volume, to be harvested and milled within the 10-year period following the date of registration of the permit, is 5368 m^3. The permits have been issued in the Ruapehu, Stratford, Tararua and Wanganui Districts.

ECOSYSTEMS INDICATORS

- **PRESSURE**: pests of indigenous habitats and native timber harvest.
- **STATE**: presence or absence of keystone species the state of vegetation in high value conservation areas.
- **RESPONSE**: area of indigenous habitat protected through voluntary agreement (not reported).

A total of 37 personal use applications have been approved within the Ruapehu, Rangitikei, Tararua, Wanganui and Manawatu Districts. The applications apply to the native timber harvesting of a total volume of 1315 m^3.

Within the region, 15 native tree species have been approved for harvesting. Forty-six percent of the species harvested are tawa trees and 27 percent are rimu. The remaining 13 species have a total harvest volume of 1956 m^3 (27 percent of the approved volume).



Extensive bush-felling, prior to burning, early this century, Pohangina valley. (Palmerston North Public Library)

At the end of 1993 a total of 49 m^3 was approved for personal use harvesting. During 1994 the volume more than tripled to a total of 210 m^3. The largest increase in volume was in 1996 when a further 530 m^3 was approved for personal use. At the end of 1997 the total volume for personal use applications was 1315 m^3.

SUMMARY

The numbers of applications to harvest native timber have been steadily increasing since 1993. Approved harvesting of native timber takes place in the Ruapehu, Rangitikei, Stratford, Wanganui, Manawatu and Tararua Districts. The sustainable forest management plan and permits cover a total area of 3313 hectares. The largest volume of abstraction approved is in the Ruapehu District.

BIRDS MONITORING ECOSYSTEM HEALTH (state)

Birds have co-evolved with New Zealand's plants throughout its long isolation—80 million years detached from other land masses. The result is some of the most unique species in the world. Thus, their presence or absence provides a simple rapid assessment of a long-term prognosis of a habitat indicating particular pressures, for example from pests or isolation and small habitat size.

Some birds and plants have evolved mutually dependent relationships in which, in the long term, the one cannot survive without the other. These **keystone** species are vitally important for the survival of native ecosystems, For example, birds such as Tui, Stitchbirds and Bellbirds double as both pollinators and seed distributors of native shrubs and trees. Kereru are essential to the propagation of large seeding native trees such as Matai, Miro, Tawa and Karaka. Introduced Silvereyes and Blackbirds occupy a wide range of native and naturalised habitats and are proficient seed distributors of native and exotic trees and shrubs.

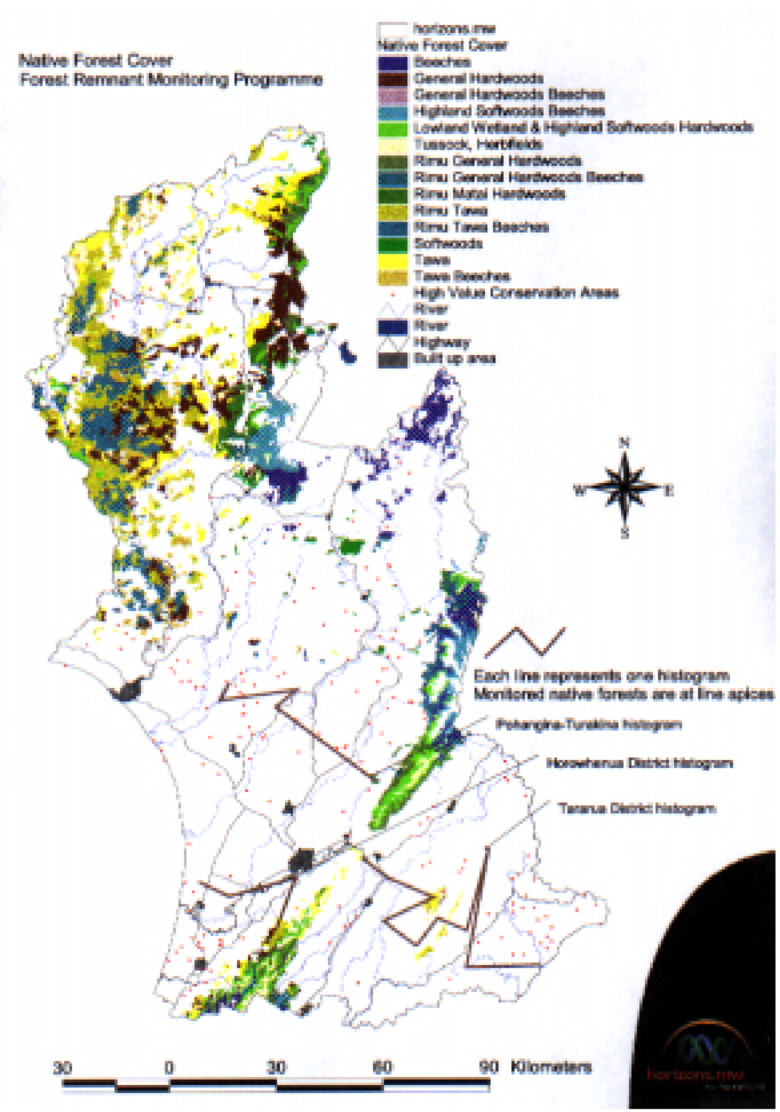
Indicator birds are those natives, Robins and Tits for example, that are specific in their choice of, and do not leave their native forest habitat. Rifleman and Whitehead predominantly live and breed in the North Island beech forests. However they can also be found in native lowland forest and in exotic forests with a native understory. The presence of Kaka indicates that the lowland native forest habitat may still be intact, producing the large old trees that provide food and nesting sites. Parakeet populations indicate a native habitat that has not yet been overwhelmed by rats and stoats.

METHODOLOGY

Our case study provides information on the presence/absence of both keystone as well as indicator birds.

Surveys were taken in forest remnants along three survey lines (Map 3):

- **Horowhenua Survey**: four sites near the Tokomaru River, in the forests, foothills of the Tararua Ranges, out at Roundbush on the Horowhenua Plains
- **Pohangina-Turakina Survey**: five forest remnants were sampled, starting at Totara Reserve about five kilometres from the south-western Ruahine ranges, out to Sutherlands Reserve on the Turakina River



MAP 3: RIVER CATCHMENTS, NATIVE FOREST COVER TYPES, MONITORED FOREST REMNANTS

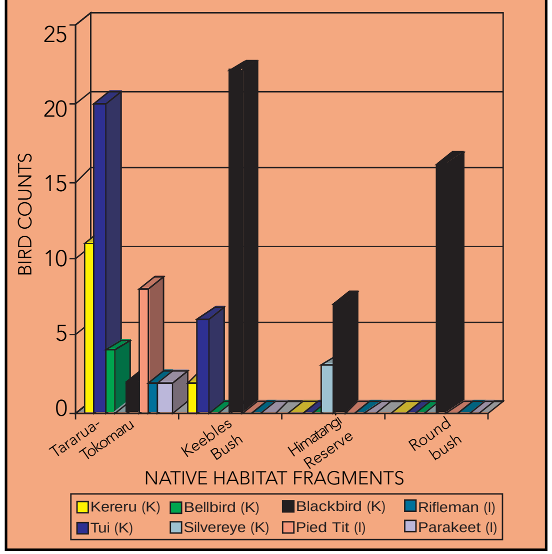
◆ **Tararua Survey**: 10 sites starting at the Manawatu Gorge and leading to the Akitio Bush Hill on the east coast.

Each site was sampled 10 times in December 1998 and January 1999, recording indicator and keystone species presence. The case study does not provide scientific data on absolute abundance or population size in the monitored habitat. It does, however, give an indication of bird population size and is therefore useful to assess habitat quality.

RESULTS

The Horowhenua District survey clearly showed a strong drop-off in keystone and indicator species the further the sites were from the Tararua Ranges. The Tokomaru River site in the forested foothills of the Tararua Ranges (Figure 5) was the only habitat where we encountered indicator birds (Tomtits and Riflemen) that typically inhabit the interior of the native forests. A few keystone birds (Tui, Bellbird, Kereru) were also present. The low number of Blackbirds and Silvereyes suggests that native birds still hold their own.

FIGURE 5: Keystone and indicator birds present in Horowhenua District bush remnants



We found only Tui and Kereru keystone species at the Keebles Bush site, 12 hectares in size and isolated from the nearest substantial native forest tracts by 10km. Both species are capable of traversing cleared land to reach native forest habitats that are within visible range. However no native birds were found in Himatangi Reserve and Round Bush. These habitats seem too isolated and small to sustain a viable bird population. Thousands of flowering native flax near the coastal Kahikatea-Puketea wetland forest of Round Bush seemed to wait in vain for the visit of a Tui or Bellbird to pollinate their flowers.

The two other survey lines show similar trends, of decreasing bird abundance and diversity with increasing isolation and also decreasing remnant size. The only difference is that native keystone species can still be found in sizeable bush remnants, the isolation of which suggests these birds are direct descendants of individuals which survived earlier forest clearance. Should they die out, they are unlikely to be replaced, and the viability of these bush remnants, too, will be questionable.

WHAT'S LEFT: EXTENT OF INDIGENOUS VEGETATION IN REMNANTS (state)

Once we gain access to recent satellite information in a Geographic Information System, a precise and comprehensive estimate of coverage of indigenous vegetation can be made. Until then, using stereo aerial photo analysis of samples, we continue with rough estimates of the percentages of indigenous vegetation in the hill country and sand country.


Manawatu Gorge, White Horse Rapid.

HILL COUNTRY

A sample of 45 randomly chosen hill country sites shows about 27 percent of the sample area was clothed in native forest or scrub (scrub includes areas of regenerating hardwood trees as well as areas of manuka and kanuka). The native vegetation was not evenly distributed. Twelve sites around the Whanganui River were 50 to 100 percent native vegetation, averaging 80 percent. The other 33 sites had 0 to 24 percent native vegetation, averaging seven percent. A third of the hill country sample of gullies and stream banks had a dense cover of native forest, and another fifth had mixed pasture and native trees or scrub.

Tree cover is an important influence on the habitat for invertebrates and fish, because it reduces both temperature and sediment inundation. Some 23 percent of the streambanks surveyed had a dense tree cover, 42 percent had mixed trees and pasture and 35 percent had pasture.

CONCLUSION: ARE OUR NATIVE REMNANT ECOSYSTEMS IN CRISIS?

The number and diversity of birds in a forest remnant largely depends on both the size of the remnant and the connectivity of native habitats through the landscape. A decline of biodiversity and ecosystem resilience correlates with increasing habitat isolation and decreasing size of a forest remnant. Kereru and Tui, in particular, may fly several kilometres over deforested land to reach another forest. Most native birds however, particularly the other indicator birds, do not venture outside forests, inhabiting the forest interior. Where forest remnants are small with large perimeters, native bird populations like Robins, Tomtits and Kaka are detrimentally affected by their reduced habitat in the forest interior.

Although the absence of the birds themselves is something for concern, importantly, their absence is also signalling ecosystems in crisis. Their absence indicates overall ecosystems functioning may be failing, where pollination and seed dispersal is not occurring. The viability of the smaller stands of native bush dotting the region must be questioned.

Both horizons.mw and DoC control pests in many native forest remnants. Council offers grants to farmers to fence their native forest remnants. Both actions help to slow the continuing loss of native biodiversity. By themselves, however, they do not provide a long-term solution.

Unless there is some connection with one another, native forest remnants will continue to lose vitality. Native birds need a landscape of treed corridors to reach other populations. Only then can inbreeding, with consequential risk of loss of genetic diversity, and the dying out of isolated populations, be avoided for both plants and animals.

Reference

Janssen, H. (1999) "Bush remnant viability: preliminary observations". Internal report, horizons.mw.

INVADERS: EFFECTS OF PLANT AND ANIMAL PESTS ON NATURAL ECOSYSTEMS

THE ISSUE

As discussed in the previous section, New Zealand has some of the most unique ecosystems in the world. These have evolved in the absence of many of the plant and animal pests that have taken up residence here in the last 160 years or so. Some of these introduced species are causing profound changes to our natural ecosystems. A few of the more drastic examples:

- Old Man's Beard has almost totally smothered the canopy of some farmland remnants of forest around Taihape and Pahiatua.
- Since the 1950s possums have completely removed the Rata-Kamahi canopy on more than half of the Ruahine range, leaving it with a canopy of Mahoe, Leatherwood and Horopito. The occasional podocarp tree still emerges about 10 metres above today's canopy, as if to provide a marker of where the glorious Rata-Kamahi canopy once was.
- The forests around the northern Ruahines and Hihitahi have now lost most of the Mountain Cedar trees (also known as Kaikawaka or Pahautea), and possums have started to kill Halls Totara. To prevent possums from causing further canopy collapse to these forests the Department of Conservation (DoC) has started a possum control programme.
- Following possum control in Mangaweka Scenic Reserve, DoC staff were surprised to discover native mistletoe plants. Previously not known to exist in the reserve, presumably they were so eaten back that no one noticed them. After possum control, DoC also measured a large increase in size and number of known mistletoes on the southern slopes of Ruapehu.
- Following possum control from the Tararuas to the coast, south of Levin, increased native bird numbers have been informally reported.
- Predators such as stoats, ferrets, cats, rats, dogs and possums have been responsible for the extinction of perhaps 20 percent of New Zealand's unique bird species. Outside a small number of reserves, where DoC is carrying out sustained and expensive predator control, ongoing predation of Kiwi juveniles is causing Kiwi populations to decline at an alarming 5 percent per year.

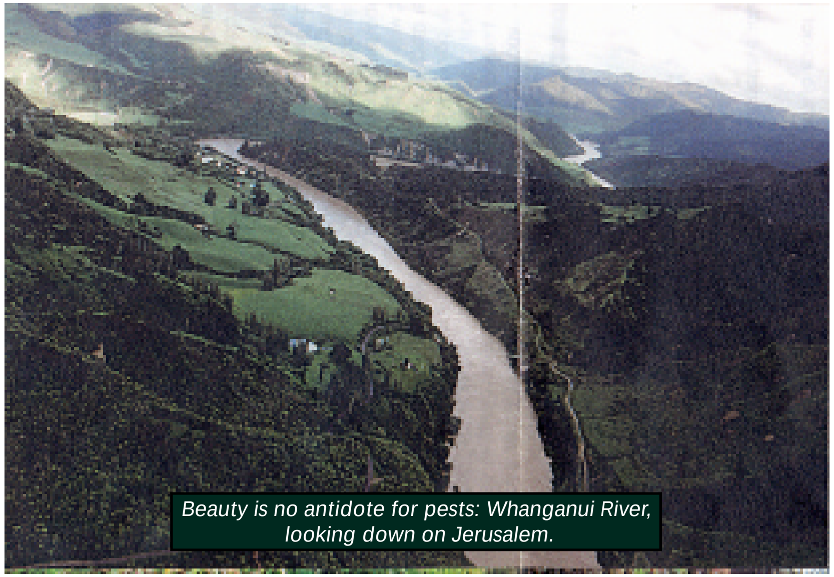
horizons.mw is responsible for setting and implementing policies to manage our region's biosecurity, under the Biosecurity Act. Regional Pest Management Strategies are prepared for both plant and animal pests that pose threats to our region's well-being. Both economic and biodiversity criteria are used to determine the threat these aliens present, and to what extent they should be controlled. In many cases the distinctions can be blurred – possums are loathed for destroying native vegetation and for spreading bovine tuberculosis, a significant threat to our agriculture. Accordingly, we report on both agricultural and ecosystem pests in this section.


Result of possum browse, causing canopy collapse in the Pohangina Valley. Note the difference between the lower branches of podocorps and the existing canopy.

VEGETATION THREATS (state)

This section discusses only pests of natural ecosystems, agricultural pests are excluded. It is in three parts, each in relation to the relevant section of the Regional Plant Pest Management Strategy (RPPMS) prepared under the Biosecurity Act:

- named RPPMS plant pests – action required by landowners or horizons.mw
- surveillance pests – nationally prohibited from propagation and sale, but no action required
- other pests – not on the surveillance list.



Beauty is no antidote for pests: Whanganui River, looking down on Jerusalem.

NAMED PESTS IN THE REGIONAL PLANT PEST MANAGEMENT STRATEGY

- Cathedral Bells is a vine that can smother native remnants. The RPPMS objective is to eliminate all known infestations in the region by July 2001. There are under 20 known infestations, all of which have been successfully controlled. Ongoing control of existing sites required. New infestations still being discovered.
- Goats Rue is widespread in rivers in the southern half of the region. Control efforts focused on preventing spread onto farm land via river metal. However, in the south of the Tararua District and parts of the Manawatu, is also out of control on farmland.
- Wild Ginger is a significant weed of the forest understory. Outside the region it is widespread in urban gardens in Palmerston North and Wanganui but is under control in other areas and not causing problems for native forest remnants.
- Old Man's Beard. The total area of Old Man's Beard estimated at over 8000 ha in 1996. A decrease of Old Man's Beard was reported in the Tararua District and Wanganui. In other areas, council efforts in spreading bio-control agents and co-ordinating Task Force Green control have caused localised reductions in the area of Old Man's Beard, but overall, probably still increasing. Best hope is that the bio-control agents being released will reduce the vigour of the pest in the long term.
- Pinus contorta is a serious weed of natural tussock grasslands, originally introduced for soil conservation purposes. On track to be eliminated from the slopes of Ruapehu and the Waiouru Army land by 2006. Not known outside this area.
- Pampas is a potential weed of rivers and riparian zones. Currently little information about its extent on these areas.
- Scottish Heather, introduced to Tongariro National Park many years ago by an over-zealous and home-sick park ranger. Has invaded the natural tussock grasslands around Mt Ruapehu, accelerating succession of grassland to native scrub. Has decreased on the western side of the mountain, due to DoC and Council funded control, but has increased on the eastern side.
- Woolly Nightshade is a common weed in Wanganui City. Occasional sites are also found in the Horowhenua, Manawatu and Rangitikei. Has the potential to invade native shrublands and riparian zones. All known infestations of Woolly Nightshade have been controlled.

SURVEILLANCE PESTS UNDER THE REGIONAL PLANT PEST MANAGEMENT STRATEGY

- Alligator Weed. An outbreak of this at the Taumarunui sewage treatment plant in 1998. After spraying, a monitoring programme initiated, in an effort to prevent it spreading down the Wanganui River, and to eradicate it.

- Banana Passionfruit, a creeping vine that smothers trees in small bush remnants. Spread by birds, it is now on the increase in the Wanganui, northern Manawatu and Southern Rangitikei.
- Ivy, reported to be stable around Taumarunui, Taihape, Palmerston North and Levin but increasing around Wanganui and Marton.
- Purple Loosestrife, an infestation on Lake Horowhenua has decreased because of a council funded control programme, while a smaller infestation in Virginia Lake, Wanganui, does not require control.
- Spartina, DoC has a programme to control Spartina in the Manawatu estuary.
- Other surveillance weeds of natural areas at low levels but on the increase are Mignonette Vine, Climbing Asparagus, Moth Plant, Japanese Honeysuckle, Boneseed and Himalayan Honeysuckle.

OTHER PESTS

Other non-surveillance weeds not on the surveillance list and not being monitored include Convolvulus, and Tradescantia.

HVCA VEGETATION (state)

To date, canopy browse plots have been established in eleven HVCAs to determine the effects of possums and possum control on canopy trees. Possum browsed tree species were assessed for foliage density, possum browse and dieback. Results are summarised in the table below.

The main concerns are for Rata and Kamahi trees, dying in significant numbers. The results show that sustained possum control can halt and also slowly reverse possum damage to native trees. Effective possum control is particularly needed in bush remnants that contain these trees. Houhere, Titoki, Totara, Mamaku, Mahoe and Tawa were also found to suffer localised damage.

HVCA VEGETATION

FOREST AREA	VEGETATION STATE
Ruahine Range	The former Rata-Kamahi forest largely collapsed, leaving Mahoe-leatherwood scrub. Beech forest and Ruahine corner still intact, the latter now under possum control to protect remaining Mountain Cedar and Hall's Totara.
Hihitahi	Most of the Mountain Cedar dead but ongoing possum control is protecting Hall's Totara from further decline.
Whanganui National Park	The same ecosystem destruction wrought by deer and possums in the Ruahines is established in Whanganui National Park, held in check by DoC pest control.
Tararua Range	Recent possum control has increased native bird numbers.
Mt Ruapehu	Recent possum and predator control has increased native bird numbers, allowed kiwi to breed, and enabled regeneration of native mistletoes amongst beech forest.
Farmland remnants	Inside TB control operational zones, possums being held at low levels. Forest structure is being maintained, but ground-level browsing is preventing regeneration in most sites. Outside TB operations, possums are at high levels. Possums killing Rata, Kamahi, Kaikawaka, Halls Totara.

horizons.mw controls animal pests under two Pest Management Strategies: the National Strategy for control of Bovine Tuberculosis and the Regional Animal Pest Management Strategy (RAPMS).

FIGURE 6: Effect of RCD on rabbit numbers in rabbit-prone areas

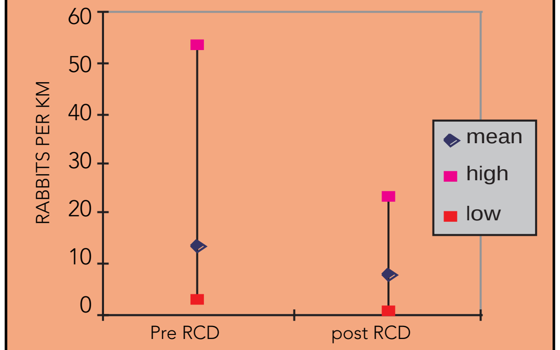
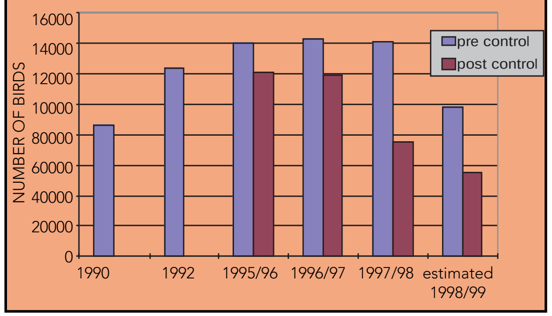


FIGURE 7: Rook population trends: 1990 to 1998



NATIONAL STRATEGY FOR CONTROL OF BOVINE TUBERCULOSIS (response)

Bovine tuberculosis is a major economic risk to New Zealand's cattle and deer industries. In order to safeguard our beef and deer trade, New Zealand must be seen to be making significant progress in reducing TB to very low levels.

The national goal is to reduce the number of infected herds to 0.2 percent in the 'vector free areas' outside TB control operations, and to reduce the number of infected herds to 11 percent in the 'vector risk areas' inside TB operations, by 2003. The Manawatu-Wanganui Region is on track to achieve that goal, with the number of infected herds having halved in the last two years.

horizons.mw has a huge annual budget (around $7 million) for possum control to prevent possums from re-infecting cattle with bovine tuberculosis (TB). Operations cover 35 percent of the region.

REGIONAL ANIMAL PEST MANAGEMENT STRATEGY (response)

Very much the small brother to possum control under the National TB Strategy, the Regional Animal Pest Management Strategy involves spending nearly $1 million per year to control possums, rabbits, rooks and goats.

RABBITS, ROOKS, POSSUMS AND GOATS

Rabbit numbers are low throughout most of the region. Two exceptions to this trend are in parts of the coastal sand country and in isolated pumice terraces in the Taumarunui area. In those areas rabbit numbers are sometimes above 10/km.

The introduction of the RAPMS in July 1996 signalled a change in emphasis for rabbit control. Since 1996, less rabbit control operations have been carried out, reducing the amount of ratepayers' money spent on rabbit control by 41 percent, from $216,000 to $89,000. This reduction in control has had no effect on rabbit numbers over most of the region. However, in some rabbit-prone areas, rabbit numbers began to climb about 1997.

The introduction of Rabbit Calicivirus Disease (RCD) in early 1998 reduced rabbit numbers by about half. Figure 6 shows the effect of RCD on horizons.mw's 11 RCD countlines, all on very rabbit-prone land. RCD reduced rabbit numbers by an average of 45 percent, from about 13 rabbits per km to about 7.5 rabbits per km. On these sites, rabbit numbers are likely to have averaged around 5 per km prior to the release of the RAPMS.

The overall result is that rabbit levels have dropped over most of the region, due to RCD. In some rabbit-prone areas, however, rabbit numbers are higher than in 1996, because increases in rabbit numbers in the absence of rabbit control outweighed the effect of RCD.

The "kaaa kaaa" call of the crows, is a familiar sound in the Tararua District, home of New Zealand's largest infestation of Rooks. Originally imported to control grass grubs, these birds are now a major pest for cropping farmers. Their cries are carried on the westerly wind as flocks of up to a few hundred birds descend on emerging or mature crops, sometimes causing significant damage.

Rook numbers were on a continual increase until 1997, when control efforts were increased substantially.

Possum and goat control by horizons.mw is targeted to High Value Environmental and Conservation Areas on private land. To date the full budget has been spent on possum control.

Although possum numbers in animals per hectare are not monitored in the region, trapcatch[4] data from seven High Value Conservation Areas is

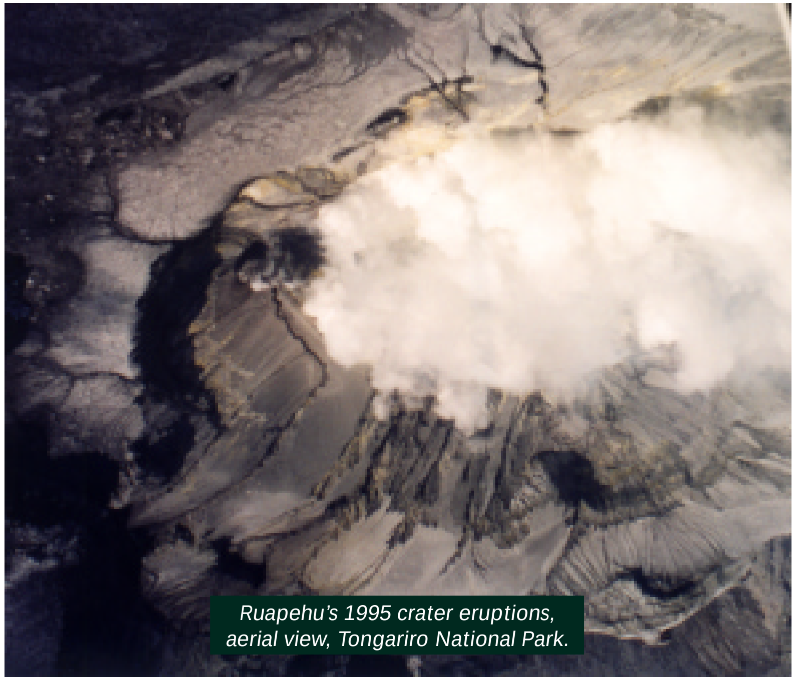
[4] *Trapcatch – percentage of monitoring traps in which possums were caught over a single night.*

available. In uncontrolled sites possum levels are generally between 25 to 40 percent trapcatch. After control, numbers can be anywhere between one to 25 percent trapcatch, depending on the rigour of the programme.

A 1-2 percent trapcatch is required to protect some rare plants from possums (eg. Woodrose), or to sustain the natural state of an entire ecosystem, while protection of species such as Totara may require only a 20 percent trapcatch.

LIFE ON THE EDGE: NATURAL HAZARDS PROGRAMME

Located on the edge of two tectonic plates, surrounded by ocean, and spanning both sub-tropical and sub-polar climate zones, New Zealand is exposed to a variety of hazards. The region faces a range of natural hazards, though exposure to individual events varies within the region. The degree of risk, risk acceptability and hazard magnitude vary with the type and geographic location of the hazard. The major hazards are earthquakes, tsunamis (tidal waves), volcanic action, flooding, and land subsidence.


Ruapehu's 1995 crater eruptions, aerial view, Tongariro National Park.

Human activity can exacerbate natural occurrences, such as flooding, sedimentation, and land slips. For example, while human activities have little or no influence over rainfall, they can alter run-off through the land management and catchment areas. Similarly, siting settlements or investing capital in hazard-prone areas, such as flood plains, increases the potential for damage should an event occur. This then forces further investment in protection works, such as stopbanks, to mitigate or avoid the effects.

The Natural Hazards Programme was developed to monitor the occurrence and consequences or risks of these natural hazards. Natural hazards are by definition largely beyond human control and their likelihood is based on probability. We have some control only over the magnitude of impact when they occur. Our focus is therefore on our response to these events. We can quantify probability and magnitude of events based on the historical record to establish our risk to these events, and by building protective works, controlling exposure to harm. Our pressure indicator is the demand by people to settle where they are at greater than normal risk.

ISSUE

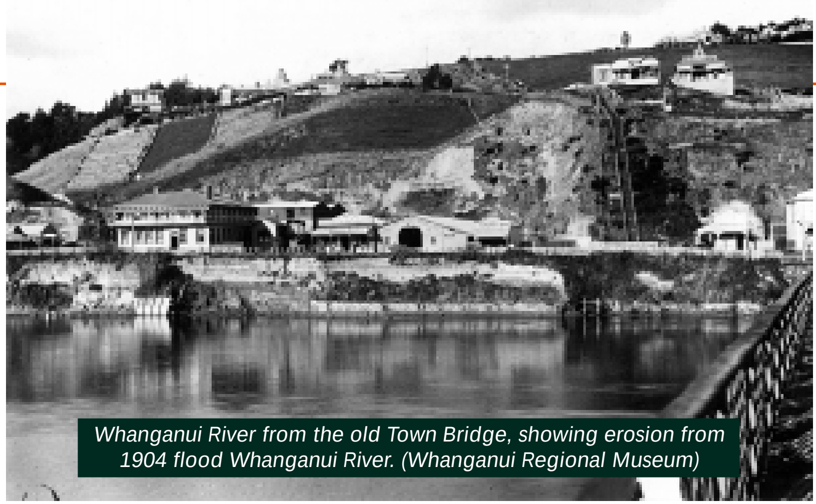
The main issue identified is the impact of natural hazards on the environment, particularly on the health and safety of individuals and communities, and the loss of physical property.

NATURAL HAZARDS INDICATORS:

- Quantifying probability of occurrence and magnitude of hazards
- Mitigating or avoiding harm.

References

Todd, M. (1998) *Plant Pest Monitoring Report*, Manawatu-Wanganui Regional Council.
Todd, M. (1998) *Animal Pest Monitoring Report*, Manawatu-Wanganui Regional Council.


Whanganui River from the old Town Bridge, showing erosion from 1904 flood Whanganui River. (Whanganui Regional Museum)

FOR THE RECORD – PROPHESIES OF DISASTER?

EARTHQUAKES

New Zealand sits on the boundary between the Indo-Pacific and Australian tectonic plates. Deep below the surface of the region, these huge plates are slowly being forced together in the subduction zone some 40 km deep inland of the east coast of the region. Large movements of these plates have caused some of the major earthquakes recorded in the region.

The major faultline in the region is the Wellington fault running just to the east of the Tararua ranges. North of the Manawatu Gorge this becomes the Mohaka fault. It is part of the main alpine faultline that runs from Fiordland in the south to White Island and beyond in the north. There are also many smaller fault-lines in the region, most notably in the Tararua District east of Dannevirke and Pahiatua, and near and offshore of the area around Wanganui and Bulls.

The impact that an earthquake has depends on three factors. The first is the intensity of the earthquake, usually measured on the open ended Richter Scale. On this logarithmic scale an earthquake of intensity 7 is very large; one of intensity 8 massive. The second factor is the depth at which an earthquake occurs. In the 1987 Edgecumbe earthquake, the intensity on the Richter Scale was "only" 6.3, but the earthquake was centred just eight kilometres underground, and it caused major damage.

The third factor is the nature of the substrate. In simple terms, the harder and more compacted the substrate, the less the impact of an earthquake of any given intensity. Conversely, the less structured and compacted a substrate is, the greater the impact. In extreme cases, soft substrates such as sand can liquefy, resulting in the soil structure completely collapsing.

In our region the sand country in the west is most vulnerable to ground movement in an earthquake. This makes much of Wanganui, which is built on recent sand and alluvial deposits, very vulnerable to major damage from a nearby earthquake of only moderate intensity. By comparison, Dannevirke, which is much closer to the main alpine fault, could be subjected to an earthquake of much greater intensity, but is less vulnerable because it is on much firmer substrate.

TABLE 5: MAJOR EARTHQUAKES RECORDED IN LAST 150 YEARS

Date	*Epicentral area*	*Richter magnitude*	*Mercali maximum intensity and location in region*
8 July 1843	Near Wanganui	7.5	IX-X, Wanganui
16 October 1848	Marlborough	7.1	VII, Levin
23 January 1855	South Wairarapa	8.0	IX, Palmerston North, Pahiatua
22 February 1863	Waipawa	7.5	VII, Dannevirke
18 August 1895	Taupo	6.5	VII-VIII, Taumarunui
8 December 1897	Wanganui	7.0	VIII, Wanganui
8 August 1904	Cape Turnagain	6.7	IX-X, Herbertville
2 February 1931	Napier	7.8	VII, Dannevirke
5 March 1934	Pahiatua	7.6	VIII, Pahiatua
24 June 1942	Masterton	7.2	VII, Eketahuna
13 May 1990	Weber	6.5	VIII, Weber

Source: IGNS.

These factors in combination form the basis of the Modified Mercali index for measuring the impact that an earthquake has at a particular site. On this scale an intensity VII event results in general alarm, difficulty experienced in standing, and possible damage to brick veneers. An intensity X event results in most unreinforced masonry structures and many buildings seriously damaged. And the most severe intensity XII event results in massive destruction of buildings.

Table 5 lists earthquakes recorded in or around our region since 1840 that have resulted in Mercali intensity VII or greater effects in the region

The table indicates that we have perhaps been lucky in the last 55 years not to have experienced major damage causing earthquakes in our region. Certainly there were far larger events in the 100 years before that.

We are unable to predict earthquakes with any accuracy whatsoever at this time. Scientists do however monitor movements on opposing sides of known fault lines and from this are able to predict generally when a major event is likely. Our recent fairly benign earthquake history suggests in itself that bigger events are likely in the reasonably near future as tension builds up on opposite sides of faultlines.

TSUNAMI

Large undersea earthquakes can cause tidal waves, usually referred to by their Japanese name of Tsunami. Recent events in Papua New Guinea have demonstrated the devastation that a tidal wave can wreak.

Both coasts of New Zealand are potentially vulnerable to tidal waves. The east coast is most vulnerable because of the large tidal waves that could be generated in the vast area of the Pacific Ocean. However, good warning systems are in place. The west coast is less vulnerable to major events, but in our region the impacts on coastal communities are likely to be much greater. Much less warning is likely if a major earthquake occurs close to the shore of the west coast.

VOLCANIC ERUPTION

The spectacular and widely reported eruption sequences of Mt Ruapehu in 1995 and 1996 mean that the volcanic threat in our region is probably uppermost in many people's minds. In a geological context however, these were but minor eruptions. The three central volcanoes are all frequently active in a geological sense, and a large eruption of either Ruapehu or Tongariro can be expected about once every 10,000 years, resulting in the eruption of around a cubic kilometre of ash and lava into the environment. In comparison, the 1974 eruption of Mt Ngauruhoe expelled less than a tenth of a cubic kilometre of ash and lava; and the 1995 and 1996 eruptions on Ruapehu less than this again.

While a major eruption of Ruapehu, Tongariro or Taranaki could have major impacts on our region, even these are minor compared with the impacts of an eruption of the Taupo, Maroa or Okataina rhyolite volcanoes. The eruption of the Taupo caldera about 1800 years ago is the largest recorded in human history. That massive explosion, which spread pumice to depths of several metres over much of the North Island, was many thousands of times larger than the recent eruptions of Mt Ruapehu. A repeat of such an event today would likely cause thousands of casualties, and rip apart the social and economic fabric of New Zealand. Fortunately for our and our children's generations, such events occur only once every few thousand years.


Whangaehu River, 1995, after lahars.

The likelihood of volcanic eruptions can be predicted with more certainty than in the past, but not with absolute accuracy. IGNS monitor activity around the crater of Mt Ruapehu, and have four levels of alert depending on the activity detected. In recent times monitoring has also started around the active Horomatangi vent of the Taupo rhyolite field.

FLOODING

Flooding is a major concern particularly on the intensively developed Manawatu and Rangitikei River floodplains. Parts of Wanganui City are also in flood-prone areas. The region has an extensive system of river control schemes, relying heavily on stopbanks and spillways.

FLOOD OCCURRENCE

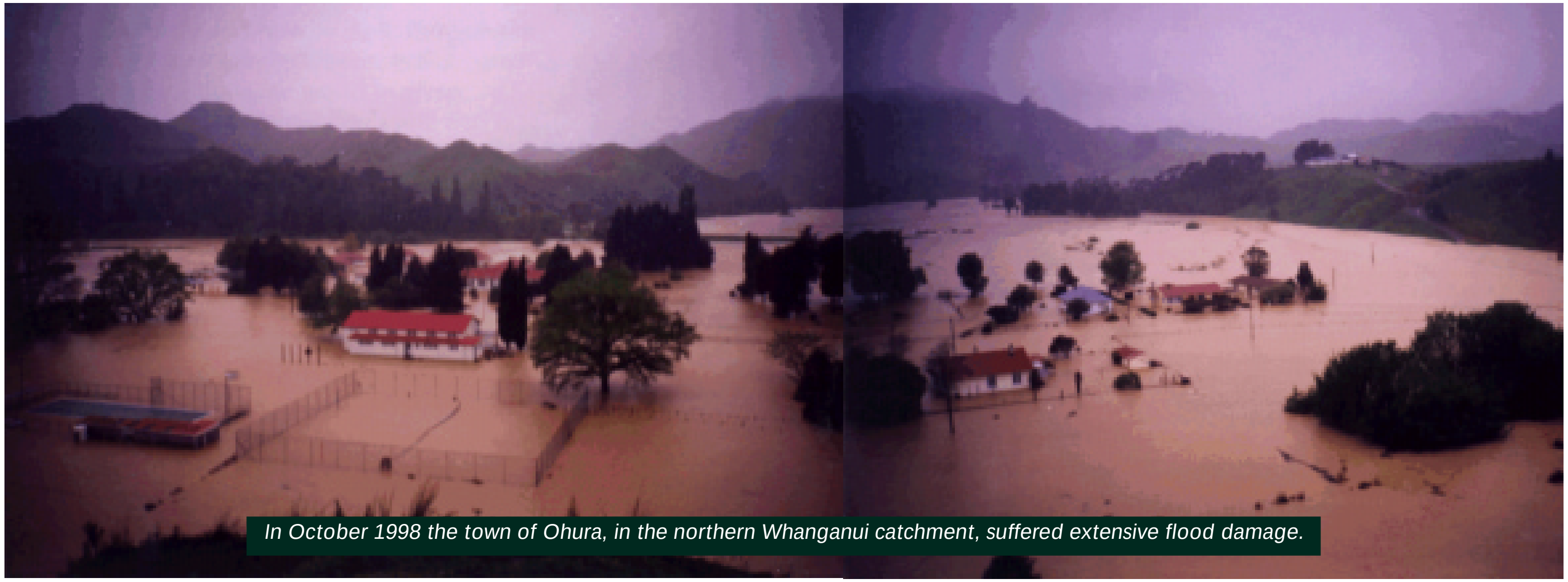
Patterns of development and settlement of the region have created significant areas now prone to flooding hazard. Communities often respond to flooding hazard by increasing protection using river controls, stopbanks and other structures, pumps and drainage networks. Once protection measures have been taken, more development is attracted to the area, "upping the ante" of risk.

Longer-term variations in climate and weather influence our perceptions of flood hazard and the effectiveness of mitigation efforts. The lower Manawatu catchment is protected by the largest flood control scheme in the region. Smaller schemes provide flood protection and erosion control in the upper catchments. Conditions in the Manawatu catchment have been relatively benign in recent years, particularly in respect to rainfall. Should rainfall patterns return to those experienced almost 50 years ago, prior to the inception of the schemes, protection works and flood control measures may repay their investment.

FLOOD HAZARD

Floods in the major catchments have been monitored and reported on since the late 1800s. Knowledge of historic floods in the smaller catchments is not as comprehensive.

The frequency of flood events influences the extent of effects on rivers and their floodplains, and has considerable impacts on the socio-economic



In October 1998 the town of Ohura, in the northern Whanganui catchment, suffered extensive flood damage.

effects of floods. The Lower Manawatu experienced a higher frequency of events prior to completion of scheme construction works in 1964. On the other hand there has been a recent absence of floods in rivers sourced in the South-East Ruahines. However the 1988 and 1992 events were large floods causing considerable siltation and damage.

The frequency of flooding experienced in 1998 in the Rangitikei and Whanganui catchments was unusual and significant; probably a La Nina event.

In October 1998 the town of Ohura, in the northern Whanganui catchment, suffered extensive damage from flooding more severe than previously experienced when two floods struck within a week. Located beside the Mangaroa River in a sedimented valley, the town has a long history of flooding, but no flood protection works. Rainfall was unusually heavy for months prior to the floods, culminating in an October record total of over 700 mm (more than 2.5 times the October average) and a peak of 200 mm overnight. Since June 1957 a record of inundation has been kept, as marks on the wall of the town's garage.

The region occasionally experiences heavy rainfalls associated with decaying tropical cyclones passing near or across New Zealand. Flooding from these events may be severe, exacerbated by wind damage and, in coastal areas, storm surges resulting from high winds and low barometric pressure. Notable events attributable to the passage of cyclones include:

- 1897 in Manawatu and Rangitikei
- flooding and severe wind damage in 1936 through the Tararuas and the upper Whanganui
- 1940 event in Whanganui
- the 1953 flood in the Manawatu River
- severe damage to the South East Ruahines in March 1975 (Alison)
- flooding in the Rangitikei and Pohangina Rivers in March 1988 (Bola)
- flooding of Wanganui in March 1990 (Hilda).

When full, Mt Ruapehu's crater lake drains into the Whangaehu River. Periodically eruptions and crater wall instability allow sudden releases of water from the lake. Floods caused by these events, known as lahars, contain large amounts of mud, rock and ash. A lahar on Christmas Eve 1953 caused New Zealand's largest rail disaster at Tangiwai. Volcanic activity in Ruapehu during September 1995 caused numerous small lahars, discharging all water from the crater lake. Lahar levels and flows were recorded at three gauges on the Whangaehu River.

FLOOD HAZARD (response)

horizons.mw manages a large network of monitoring stations, river control schemes and flood protection systems. Its Core Reference Network of the Hydrological Observation Programme provides automated warning facilities for property owners and community services affected by floods. Ten of these are located in the Manawatu catchment and one each in the Whanganui, Whangaehu and Rangitikei catchments.

All stations operated by horizons.mw, and some additional stations operated and or funded by a variety of agencies feed information on rainfall, river levels and flows to a dial-in information service. This enables individuals to monitor conditions in their area. All significant rainfall events are monitored 24 hours a day by horizons.mw staff. Data gathered from upstream rainfall stations and river gauges are used to assist in the operation of flood protection structures and ensuring an appropriate emergency response.

MITIGATING EFFECTS (response)

Mitigation of hazards is another key response. horizons.mw manages 19 flood and erosion control schemes, many of which in part offer protection against flooding. The largest such scheme is the Lower Manawatu Flood Control Scheme which protects a total of 280 square kilometres of the Manawatu Plain, including much of Palmerston North, from flooding. The recent upgrade in protection for the city secures it from an event with a predicted recurrence of over one in 1000 years. In contrast the rural area has a much lower level of protection, partly because it is not economic to protect it to the same level. horizons.mw is currently consulting with that rural community to determine what level of protection they are prepared to pay for in the future.

Other areas that have flood protection include schemes on the lower Rangitikei and Ohau rivers, and stopbanks that protect Taumarunui.

Akitio, on the region's remote East Coast.

Mitigation can also take other forms. Lahar paths on Mt Ruapehu are well mapped and buildings are not allowed in known paths. A station on the Whangaehu River will advise in advance of a lahar coming down that river and threatening the rail and road bridges at Karioi, so preventing a repeat of the tragic Tangiwai disaster of 1953.

A final measure of response is that of emergency preparedness. All local authorities in the region, along with the emergency services, have civil defence and emergency management responsibilities. We are well along the path to forming an Emergency Management Group in the region that will allow a better, more integrated response to emergencies of all kinds.

LAND STABILITY INDICATORS

- **STATE**: occurrence and location of significant hazard events
- **RESPONSE**: mitigation measures insurance claims submissions made to District Council land use consents.

LAND STABILITY

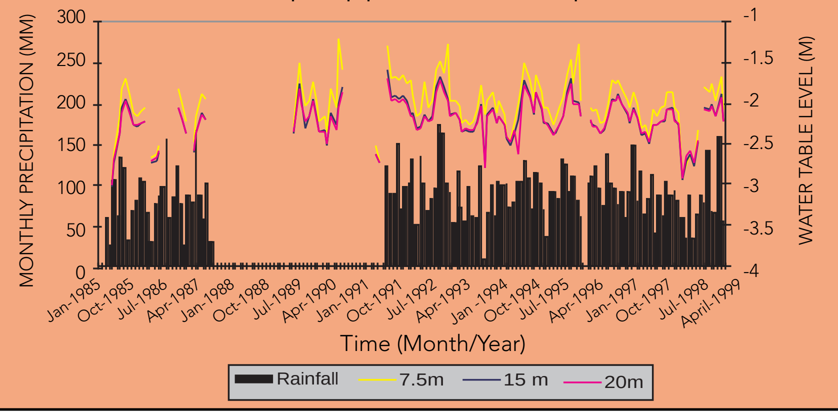
Land stability hazards include subsidence, erosion, landslip and sedimentation. Hill country, sand dunes and river banks in the region are particularly prone to erosion and landslip. Sometimes there is demand for intensive development in areas prone to subsidence, erosion and landslips. The Utiku Slump south of Taihape is an example of this.

Case study: Getting a Grip: Taihape slip monitoring

The area known as the Taihape Slip experienced a significant slope failure between 11,000 and 2000 years ago. The slip underlies a medium density housing area and also contains both a school and hospital. If the failure occurs again there is a possibility that people, property and essential services will be adversely affected.

To reduce the potential for future failures the local territorial authority has undertaken considerable slope stabilisation and land drainage improvement works. Studies during the last 15 years have found no evidence of recent movement.

FIGURE 8: Monthly precipitation totals and water table levels from the 7.5, 15, and 20 metre Taihape Slip piezometers, for the period 1985-1998



Ongoing monitoring of the slip area is carried out to detect changes in the slip's underlying conditions, and to provide early warning of future failures. A survey network covering the slip area, and within the slip, allows the slip surface to be monitored at shallow and deep levels. horizons.mw involvement includes collecting monthly watertable level data for the slip and monthly rainfall data for Taihape township to:

- identify the effects of drainage improvement works
- establish the causes of any future slip failure
- provide early warning to Civil Defence of abnormal watertable levels.

Any disruption of the established watertable-rainfall relationship would suggest a change in the slip's underlying structure, and, in particular, its drainage capacity. By contrast, an increase in watertable levels would suggest the slip was becoming saturated, with a corresponding increase in the probability of slope failure.

RESULTS

The watertable level is affected by the amount of rainfall in the previous month with watertable level peaks coinciding with either wet winters or very wet months. Levels in all three piezometers respond quickly to increases and decreases in the previous month's rainfall. No lag effects were noted where levels continue to rise, whilst monthly precipitation declined. As monthly precipitation has declined since 1995, levels have tracked downwards.

Generally, the levels in all three piezometers fluctuated about two metres below ground level, with the greatest variability shown in the 7.5 metre piezometer. Water level readings for the 15 and 20 metre piezometers are almost indistinguishable, with only one or two centimetres' difference between the two readings in any one month.

SUMMARY

The close correlation between monthly precipitation and watertable levels over the period of record indicates that since the stabilisation works there has been no significant or gradual shift in the drainage capacity of the slip. Also, it appears that post-1985 drainage improvements in the area have had minimal effect, as the strength of the above relationship is unchanged.

TABLE 6: BUILDING AND SUBDIVISION APPLICATIONS AND GENERAL PUBLIC INQUIRIES RECEIVED BY HORIZONS.MW BY NATURAL HAZARD, FOR THE PERIOD 1991-1998

Concern	*Year*	*District*						
		Tararua	*Horowhenua*	*Palmerston North*	*Manawatu*	*Rangitikei*	*Wanganui*	*Ruapehu*
Flooding	1991	0	12	6	28	6	1	4
	1992	2	15	5	15	5	0	1
	1993	3	17	7	19	2	0	0
	1994	1	14	8	10	2	2	6
	1995	2	18	5	15	3	0	6
	1996	2	16	3	15	0	0	2
	1997	0	38	5	38	1	4	3
	1998	4	28	4	22	0	4	0
	Sub-total	14	158	43	162	19	11	22
Stability	1991	1	1	1	9	1	1	4
	1992	2	1	0	3	0	0	4
	1993	1	3	0	5	0	0	2
	1994	0	6	0	3	1	0	2
	1995	0	2	1	8	0	0	4
	1996	1	2	2	2	0	5	2
	1997	1	10	0	7	0	8	2
	1998	1	13	3	4	1	15	1
	Subtotal	7	38	7	41	3	29	21
	Total	21	196	50	203	22	40	43

As far as watertable level and drainage are concerned, the conditions required to initiate slip failure have not been exceeded during the period of record. In fact, in its current state, unless we have an extremely wet month, or a prolonged wet winter, the slip is unlikely to fail.

HAZARDING AN INQUIRY: THE NUMBERS (pressure)

Although most hazards cannot be controlled, people still want to live in hazardous places. This may be for lifestyle reasons, such as on dunes close to the sea, or because of a shortage of safer land. Subdivisions and public inquiries give an indication of this pressure.

horizons.mw maintains records of applications and inquiries by district councils and the public. Thus we can identify trends in application numbers and location, whether the advice provided is being acted upon, and what the territorial authorities are doing in relation to natural hazard management.

horizons.mw limits its comments on natural hazards to two issues. One is flooding which in this context includes inundation from watercourses overtopping their banks, and surface ponding of water due to poor drainage. The other is land stability involving slips, slumps, rapid erosion, and windblow of dunes (in the coastal area). Accordingly, the following discussion is restricted to these hazards.

horizons.mw received a total of 429 inquiries relating to flooding during the period 1991-1998 (Table 6). Of these inquiries, three-quarters were for properties in the Horowhenua and Manawatu districts, reflecting the large land areas prone to flooding in these districts. This does not imply the other districts do not contain any floodable areas, rather that demand for property, particularly for rural lifestyle blocks, has not reached a level where development of floodable areas is required. There is no obvious trend in the number of flood inquiries received per year.

Over the same period, a total of 146 inquiries were received where land stability was an issue. Approximately three-quarters of these inquiries were for properties in the Horowhenua, Manawatu, or Wanganui districts. This trend is indicative of the market's desire for properties with either a view of, or proximity to the coast, where slope stability or sand dune erosion is, respectively, of concern. This is increasingly true of both the Horowhenua and Wanganui districts. Districts with the greatest slope stability problems, Rangitikei and Ruapehu, are poorly represented in these figures, indicating that property demand has not reached a level where development of more marginal land is required.

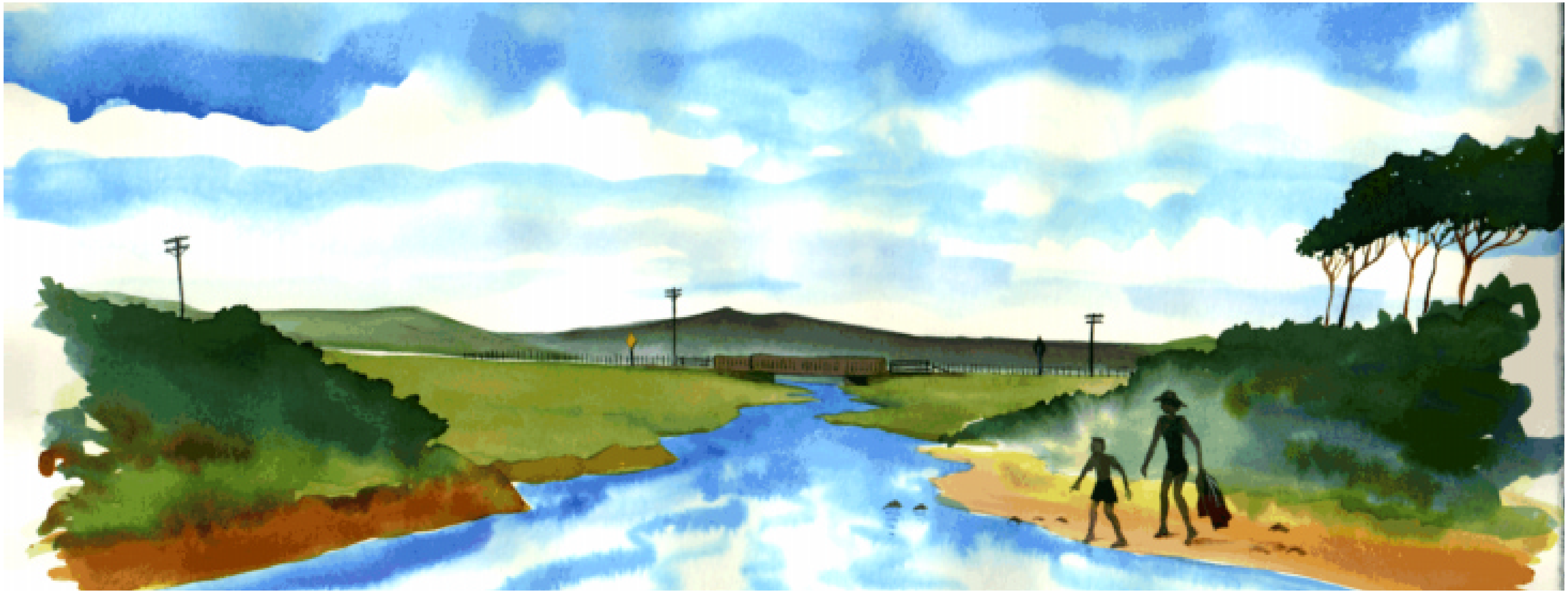
For most inquiries, the flooding issue was relatively minor. However, a large yet unknown proportion of the inquiries involved significant flooding, ie. more than 50 percent of a property was at risk from flooding. Likewise, most of the land stability issues recorded were relatively minor.

SUMMARY

Districts most affected by flooding and land stability hazards are generally those with the greatest awareness of the associated problems. As such, the territorial authorities and their constituents contact horizons.mw on flooding and land stability hazards affecting any land purchase, subdivision or building consent. By ensuring horizons.mw involvement, they lessen the future impacts of these hazards.

Jo Bachelor's "Willowbank" farm, Fitzherbert West, about 1890. Note the extensive forest remnants. (Palmerston North Public Library)

PART II



FRESHWATER

FLUVIAL SYSTEMS PROGRAMME INDICATORS

- **PRESSURE**:
  Location and column of gravel extraction
  Resource consents issued
- **STATE**:
  Change in river channel geometry
  Particle size
- **RESPONSE**:
  Compliance and incidents
  Controlling gravel extraction.

FLUVIAL SYSTEMS, SURFACE WATER QUANTITY, WATER QUALITY, GROUND WATER

Our lakes and rivers and ground water are complex systems. The banks and beds containing them, quantity and quality of water in them, the overall climate, geology and geomorphology all interact together to provide us with the physical water resources characteristic of our region. Superimposed on these are the effects of human activities, abstractions, discharges and diversions of water and our wastes, together with adjacent land uses contributing to sediment and nutrient run-off which modify these conditions.

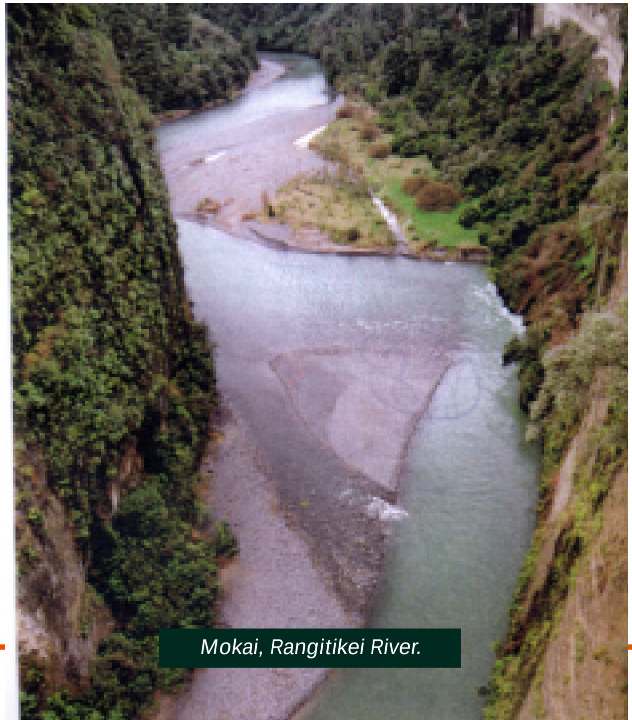
Our programmes monitor:

- the fluvial systems, that is the conditions of our riverbeds and banks
- surface water quantity and quality
- ground water quantity and quality.

A CUTTING EDGE: FLUVIAL SYSTEMS PROGRAMME

With several large, significant and characteristically different rivers within its boundaries, horizons.mw has begun to establish more than " a weather eye" on monitoring the way they behave and change. Our monitoring is designed to keep tabs on the natural and human impacts upon them.

Known as the Fluvial Systems Programme, it was developed to monitor the effect of particular activities causing changes to the depth, width, position or configuration of a river. These all have significant implications for flood and erosion control, water quality, and the ecology of in-stream flora and fauna.



Mokai, Rangitikei River.

The main issues identified are:

- impact of gravel extraction on the stability of rivers and processes of sediment transport
- disruption to fluvial systems caused by activities in the beds of rivers and on floodplains, such as river protection works, bridges, dams.

For each issue various indicators have been developed or at least identified.

GRAVEL EXTRACTION

GETTING THE BALANCE RIGHT (pressure)

River gravels are valued for their high quality for construction and roading. Until quite recently, large volumes were mined from rivers for use in local projects, usually from wherever was most convenient. Often these sites did not coincide with those locations most suited to sustainable extraction of gravel. In many cases, extraction rates were unsustainable, far exceeding natural supply. This action has been identified as a key factor in riverbed degradation and riverbank erosion.

REDUCING USE IN FAVOURED AREAS (response)

Extraction limits have now been imposed on most of the region's gravel extraction rivers (see Schedule 2 of the *Proposed Regional Plan for the Beds of Rivers and Lakes and Associated Activities*), to mitigate these effects. Furthermore, competition for the gravel resource in favoured areas, coupled with under-utilisation in remote areas, has combined to create an unhealthy imbalance in resource use.

GRAVEL EXTRACTION CONSENTS (pressure)

Gravel extractors are required to obtain resource consents from horizons.mw, providing an indication of demand and hence pressure on the environment. The main sources of supply are the Manawatu and Rangitikei catchments which account for an average of 54 and 37 percent, respectively, of the total allocated volume for the region. The greatest pressure for extraction is on the lower reaches of these two catchments. For instance, one reach accounts for approximately 70 percent of the total volume allocated for the Rangitikei catchment.

Demand is highest in these lower reaches because of the volumes of gravel available and the closeness to major end-users eg. railways, highways, and urban areas. Although the volumes for the remaining catchments are relatively small, in many cases they represent the total volume that may be removed sustainably from the catchment.

Actual takes, as opposed to allocated volumes, are approximately half of the allocated figures for the same period, reflecting the general caution of extractors in applying for volumes exceeding their likely needs, in case a large project arises.

The Manawatu and Rangitikei catchments are under the greatest extraction pressure, with this trend being most marked in their lower reaches. Most gravel extracted in the region is used for major projects such as roading. Local usage by farmers for race maintenance and farm buildings is generally low (less than five percent). However, the volumes removed for these purposes in catchments located in major agricultural areas may be considerably higher ie. 10-20 percent of the total. These figures are estimates only.

Between 1993-96 total extraction within the region was relatively stable, hovering around 500,000 m^3 per annum. The figures for 1992 are distorted by a transition from the permit to the consent system. Note also that the contribution of berm area extraction volumes to the overall extraction has increased steadily over the study period.

TABLE 7: EXTRACTION VOLUME (M^3) BY CATCHMENT AND SOURCE-TYPE 1992-98

Source	*Catchment*	*Year*							*Total*
		1992	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	
Active channel	Akitio	0	0	0	0	0	1,000	0	1,000
	Manawatu	50,680	267,522	276,861	271,499	255,338	196,697	112,053	1,430,650
	Ohau	0	8,767	8,354	13,787	15,821	20,114	25,176	92,019
	Rangitikei	49,595	196,837	134,752	123,879	198,951	163,892	133,102	1,001,008
	Turakina	0	0	0	0	0	0	0	0
	Whangaehu	3,598	22,925	19,458	15,700	112	4,289	2,408	68,490
	Whanganui	3,200	5,894	4,991	6,160	2,245	6,205	2,327	31,022
	Sub-total	107,073	501,945	444,416	431,025	472,467	392,197	275,066	2,624,189
Berm areas	Manawatu	20,221	81,285	76,694	97,790	52,097	103,828	111,863	543,778
	Rangitikei	0	0	0	0	0	17,606	60,384	77,990
	Sub-total	20,221	81,285	76,694	97,790	52,097	121,434	172,247	621,768
	Total	127,294	583,230	521,110	528,815	524,564	513,631	447,313	3,245,957

DEMAND VERSUS SUPPLY

Extraction volumes, in conjunction with the number of consents received and volumes sought, indicate that the demand for gravel from many of the region's rivers exceeds supply. All of these rivers show the adverse effects of over-extraction. Included in this category are the Ohau, Oroua, and lower Manawatu rivers. After years of increasingly severe restrictions, a gravel management strategy is at last starting to reverse a similar trend in the Mangatainoka River.

By contrast, other rivers in the region are over-supplied with gravel. We find this situation in the south-east Ruahine streams, the Pohangina and Kawhatau rivers and, on the Rangitikei River downstream from Bulls. From a river management perspective, extraction of surplus material is desirable in the south-east Ruahine streams and the lower Rangitikei River. The low demand for gravel in these catchments or reaches, however, reflects their remoteness from major end-users.

PARTICLE SIZE ANALYSIS (state)

Information on gravel size is collected for a number of reasons. By itself, it increases the knowledge of a river by providing information on the size of material available to be transported. Because particle size or size distribution determines gravel end-use, this information is of importance to major gravel extractors (most of whom also conduct size testing). For instance, sealing chip for roads requires a minimum of three broken faces. This can be achieved economically only by crushing material larger than 70 mm in diameter. Concrete gravel, by contrast, has an upper size limit, and must contain well-defined proportions of silt, sand and gravel.

Changes in the particle size characteristics in a river or at a site can, over time, indicate catchment changes or human interference. When combined with data about flow and the channel, particle size information can be used to construct models that explain gravel movement down a river.

Samples for particle size analyses may be collected at or below the surface. Sub-surface samples tend to be more representative of the material transported by a river. They are therefore preferred for comparing changes through time. By contrast, surface samples are preferred for bed load transport analyses.

Case Study: Lower Manawatu River

The Lower Manawatu River (below the Gorge) has the most complete particle size record of any river in the region. What makes the record so valuable is the methods used, and the sample collection sites, which enables result comparison and repeat surveying.

Samples were first collected for the Lower Manawatu River in 1937. Since then, some sites have been sampled up to five times. For the purposes of this discussion, only sub-surface samples were considered. The results for these samples are shown below (Table 8).

The 1937, 1985, 1997 and 1998 surveys indicate that display particle size decreases with increasing distance downstream. This pattern is not surprising because increasing distance from the sediment source, physical weathering of the individual particles (abrasion), and a diminution in stream power all reduce particle size.

Results from the 1992 survey do not, however, reflect the above pattern. This is because the July 1992 flood, immediately prior to the survey, was a significant "25 year" flood. In addition to the input of gravel from the upper catchment and tributaries, reworking of existing gravel deposits during this flood would be sufficient to cause disruption of the particle size pattern. Results from the 1997 survey indicate that the pattern was rapidly re-established following the 1992 event.

Similarly, prior to the 1998 survey, the floods of October 1998 were responsible for transporting significant volumes of finer gravel into the upper section of the Lower Manawatu River. This reduced the particle size at the three upstream sites.

By contrast, a relative increase in particle size between Fitzherbert Avenue and Linton Army Camp was the result of recent major instream channel works carried out by horizons.mw. The Fitzroy Bend cut and the Heatley Avenue protection works disturbed the river bed, allowing transport of coarser gravels during the October 1998 floods.

Case study: Sustainable gravel levels: Makuriiti River

As a valuable gravel source the Makuriiti Stream provides hard, crushable gravel in sufficient quantities for roading purposes in its region. It is one of a limited number of river gravel sources within a large area east of Pahiatua. Since this is a catchment with a long history of gravel extraction, it provides an excellent benchmark for monitoring and measurement.

The Makuriiti Stream rises in the central Waewaepa Range, east of Pahiatua. The catchment flows in a south-south-east direction to enter

TABLE 8: D_{50} AND D_{85} VALUES (IN MILLIMETRES) FOR SUB-SURFACE SAMPLES COLLECTED AT 12 SITES ON THE LOWER MANAWATU RIVER, BETWEEN 1937 AND 1998

Site Name	*1937*		*1985*		*1992*		*1997*		*1998*	
	D_{50}	D_{85}	D_{50}	D_{85}	D_{50}	D_{85}	D_{50}	D_{85}	D_{50}	D_{85}
Pohangina confluence							73	135	16	90
Raukawa Road							40	>120	13	96
Te Matai Road							26	84	22	80
Forest Hill Road							25	96	24	58
Ruahine Street					15.3	35.8	20	79	17	65
Albert Street					16.2	40.2	17	38	17	65
Fitzherbert Avenue	56.5	79.3	27.6	69.6	21.4	42.2	17	38	25	75
Massey University							13	37	27	90
Linton Army Camp							11	30	17	37
Longburn Rail Bridge	31.6	59.3			19.6	38.3	20	40	16	50
Karere Road	27.5	68.1					13	33	16	50
Rangitane Road	8	18.4					7	25	16	51

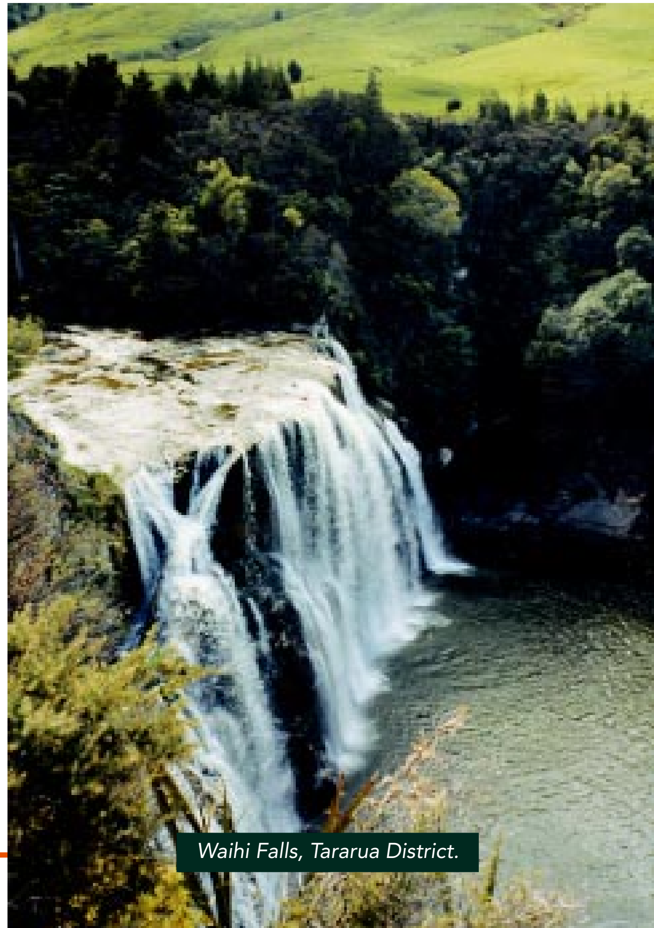
D_{50} – the clast size 50 percent of the sample weight is finer than, or the median clast size by weight.

the Makuri River north of Makuri. The western and eastern catchment areas are separated by the Makuri Fault.

Erosion is slight to moderate in the western catchment, but only slight in the east. Most of the gravel in the Makuriiti Stream is therefore derived from the western catchment, and is of greywacke.

As a recognised trout spawning habitat, during the 1980's concerns were raised that gravel extraction was exceeding the natural rate of replenishment in the Makuriiti Stream. This was deepening the longitudinal profile of the stream, and increasing channel bed and bank instability. Increased suspended sediment loads were of particular concern to anglers.

In response, the volume of gravel available for extraction was severely reduced in 1989/90. A reduced restriction continues today. horizons.mw's Proposed Regional Beds of Rivers and Lakes and Associated Activities Plan recommends an annual extraction limit of 6000m^3 from the Makuriiti catchment. To monitor the long-term effectiveness of this reduction we have established a survey reach, covering 1.5 km of the Makuriiti Stream, over the extraction area.



Waihi Falls, Tararua District.

CONCLUSIONS

The D_{50} and D_{85} particle size statistics decreased markedly between 1937 and our most recent surveys. Channel or climate changes may have contributed to this trend. However the two most likely explanations are changes in source material and gravel extraction. In 1937 the river was able to source larger material from bank erosion. Because of bank protection and river training works this recharge mechanism is virtually non-existent today. Furthermore, today's gravel extractors possess the technology enabling them to remove and process all gravel sizes encountered. In 1937 the finer material would have been favoured over the coarser. Consequently, apparent particle size in 1937 may have been boosted by preferential removal of the finer material. In recent years particle size has probably been reduced by extractors' ability to remove all gravel sizes, and the removal of a potential source of larger material.

A reduction in particle size, particularly of the D_{85} statistic, indicates that there are fewer large particles available to "armour" or secure the bed. The Manawatu River bed is consequently probably more mobile now than in 1937. This has consequences for aquatic invertebrates in terms of population size, density and composition, which in turn impacts upon such things as trout numbers and size. Once again, we see the close relationship between seemingly mechanical factors such as gravel movement and the ecosystem, of which this is a part, for living plants and animals.

Irrespective of the particle size reduction, a significant flood of mean annual discharge or larger, is still required to initiate widespread movement of the Manawatu River bed material. Accordingly, from a biological viewpoint the particle size reduction, and corresponding decrease in bed stability, is not considered a limiting factor at this time.

CHANNEL CHANGE AND GRAVEL EXTRACTION

The survey established 11 cross-sections to monitor channel changes in response to gravel extraction. Here five surveys were made between July 1988 and February 1990. Changes in volume were calculated from these surveys, then compared with gravel extraction records to determine if extraction was having any effect on the channel.

All sections degraded (ie. recorded a lowering of mean bed level and suffered a corresponding loss of gravel), over the study period. The greatest gravel losses occurred where it was most easily accessible to extractors. The downstream sections of the survey reach also experienced significant channel degradation because they were being 'starved' of gravel. In contrast, the smallest losses occurred at sections with difficult access, or were located near gravel input points at the upstream end of the study reach and tributary confluences. Recharge of gravel to the study reach was coincident with significant rainfall events.

CONCLUSIONS

Total extraction for the study period, July 1989 to February 1990, was about 20,000 m^3, at an average of 13,300 m^3 per annum. The total loss of material within the reach over the same period was about 13,000 m^3, at an annual degradation rate of 8700 m^3. From this we concluded:

- the Makuriiti Stream is degrading
- that degradation is the direct result of gravel extraction
- the average annual transport rate of the Makuriiti Stream is in the vicinity of 4600 m^3 (the annual extraction rate minus the annual degradation rate)
- a sustainable gravel rate would be about 4000 m^3 per annum.

The negative impacts of this degradation are:

- less gravel is stored in the study reach. This means less available to the stream during floods, leaving banks to erode and channel stability to decrease. There is also less gravel available to extractors
- more bedrock (papa mudstone) is exposed in the channel, making the channel less desirable for aquatic life, and more difficult for trout passage.

The positive impacts are that channel degradation increases channel capacity, thereby reducing flooding on neighbouring land. Flooding is not, however, a big issue in this catchment.

Although these were intensive surveys, the period of record is too short to draw more than indicative conclusions. For instance, gravel recharge to the study reach is strongly linked to storm magnitude and frequency, so several years of records are required to calculate a long-term average transport rate. Accordingly, further monitoring of Makuriiti Stream is planned over the next five years.

HOLDING OUR OWN: SURFACE WATER QUANTITY

The weather above, and the geology and soils below, have the greatest influence on the quantity of natural surface water available to flow over the land in our rivers and streams. Yet management of surface water has become essential to our well being and survival and horizons.mw has a range of policies and plans for this purpose.

THE ISSUES

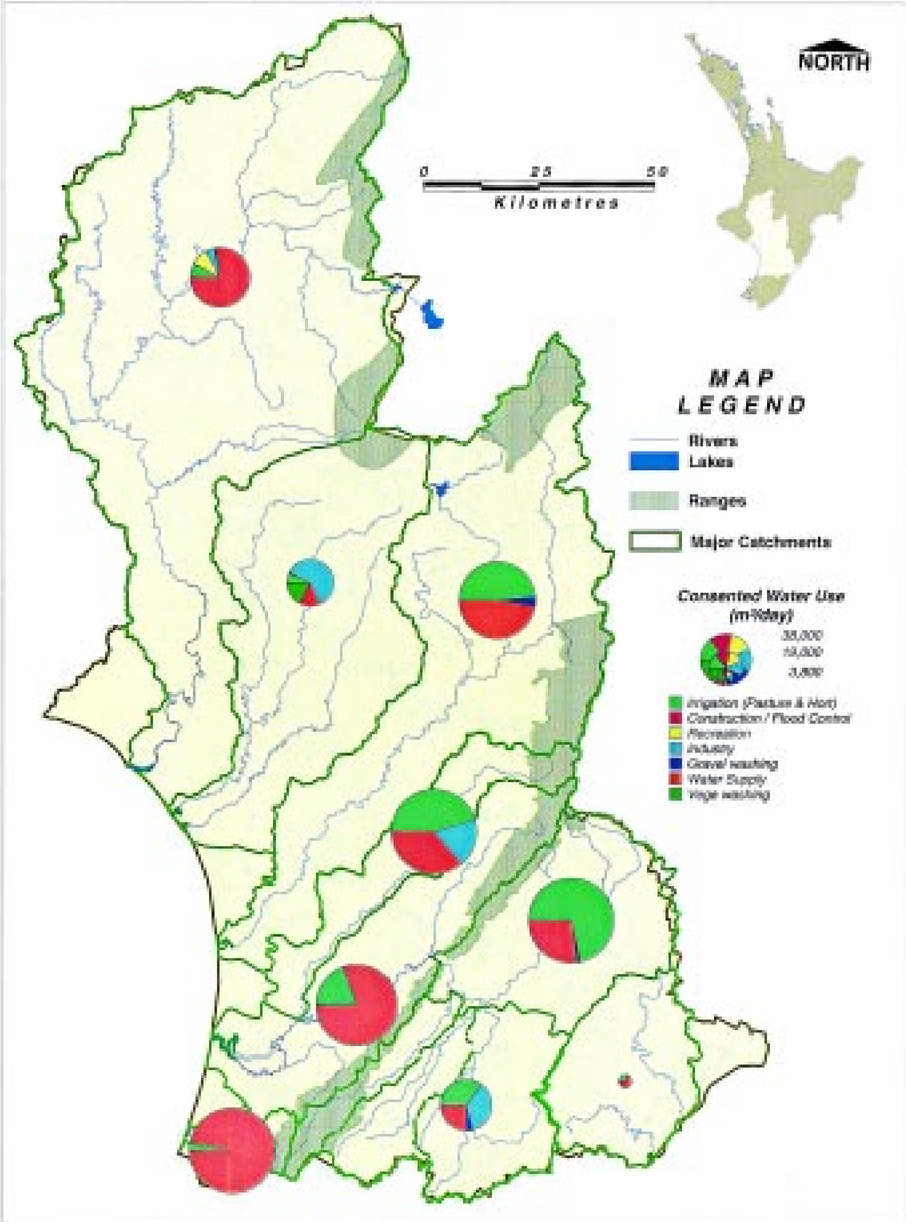
The Water Quantity Programme identifies three major water quantity issues:

- availability of the water resource
- effects of modified flow regimes on ecosystems
- occurrence of flood hazard (see Natural Hazards Section for reporting on this issue).

The council maintains a network of stations at which data are collected about rainfalls, river heights and river flows throughout the region.

SURFACE WATER QUANTITY INDICATORS

- **PRESSURE:** number of consents issued, showing demand for water
- **STATE:** river flows and rainfall, determining water availability
- **RESPONSE:** minimum flow regimes to cope with shortages



MAP 4: LOCATIONS OF ALL CURRENT CONSENTS FOR SURFACE WATER USE

DEMANDS FOR WATER (pressure)

Water may be consumed, dammed or diverted, or used to assimilate and transport waste. Often when it is consumed in large quantities there is a corresponding need to discharge and assimilate waste water. We report on activities impacting on water quantity. Information about discharges to water is found in the Waste and Water Quality sections.

Diversions may be of three types:

- water returned to the river after a short distance
- water transferred to another watercourse within the region
- water diverted out of the region.

Rivers and streams may be dammed to enhance consumption, to assist diversion, reduce flood hazard, or create wildlife and recreational features.

Resource use is managed by the consent process. Abstractions of surface water less then 15 m^3 per day and dams less than three metres high are permitted activities. They are therefore not part of the consent process. There are also many small dams throughout the region; the majority storing water for on-farm use. No information is available on the effects of any of these dams, nor are records kept of small abstractions.

Map 4 shows the location of all current consents for surface water use. We see surface water use is concentrated around population centres, in areas where rainfall is not plentiful all year round, in areas where irrigation of pasture is required, and where hydro-electricity schemes have been built.

Projections based on existing demand (Figure 9) show there is no appreciable decline in apparent future demand for surface water over the next few years. Yet in the already pressured Ohau, Oroua and upper Manawatu catchments little if any water is available for new consents to take surface water, or for increased amounts on renewal of existing consents.

The maximum daily quantities consented for use in generating electricity are many times greater than for any other type of use but the maximums are occasional, brief peaks, the result of natural variation in flow of the rivers. For this reason, the measure of abstraction is the total average capacity for electricity generation. Throughout the region it is about 50 m^3 per second.

Most of the abstractions and diversions for hydro electricity, comprising 60 percent of the total regional capacity, are around Mt Ruapehu. These are part of the Tongariro Power Development now operated by Genesis Power. All of this water is diverted out of the region via Lakes Rotoaira and Taupo, into the Waikato River. Since the scheme was commissioned in the 1970s, various controls have been placed on the use of the water to mitigate down stream effects of the abstractions. One of the most important controls has been the setting of minimum flows. Another, much smaller station at Piriaka, near Taumarunui, generates electricity below the Tongariro Power Development in the Whanganui.

The 75-year-old Mangahao scheme lies in Tararuas. Water dammed in the headwaters of the Mangahao and Tokomaru is diverted through the power station near Shannon, and discharged into the Mangaore Stream. The scheme's significance is that the water is piped through the axial range. Normally most of the water would flow into the Manawatu River at Woodville, but under the scheme it bypasses some 100 km of river channel. Reservoir storage is limited and flood flows overtop the dams to pour down the Mangahao and Manawatu Rivers.

The other hydro-electricity plants are small run-of-the-river schemes that have minimal and localised impact on the surface water resource.

FIGURE 9: Projected demand for surface water in Manawatu-Wanganui region

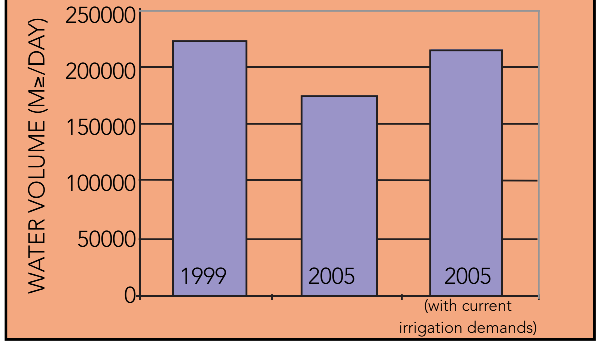
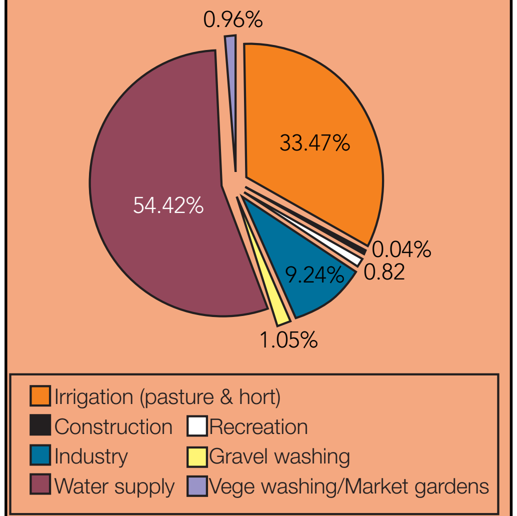


FIGURE 10: Consented abstraction of surface water in Manawatu-Wanganui region



Consented abstraction of surface water, other than for electricity generation, totals 250,000 m^3 per day throughout the region (Figure 10). Because not all consents are fully exercised at all times actual abstractions are less than this.

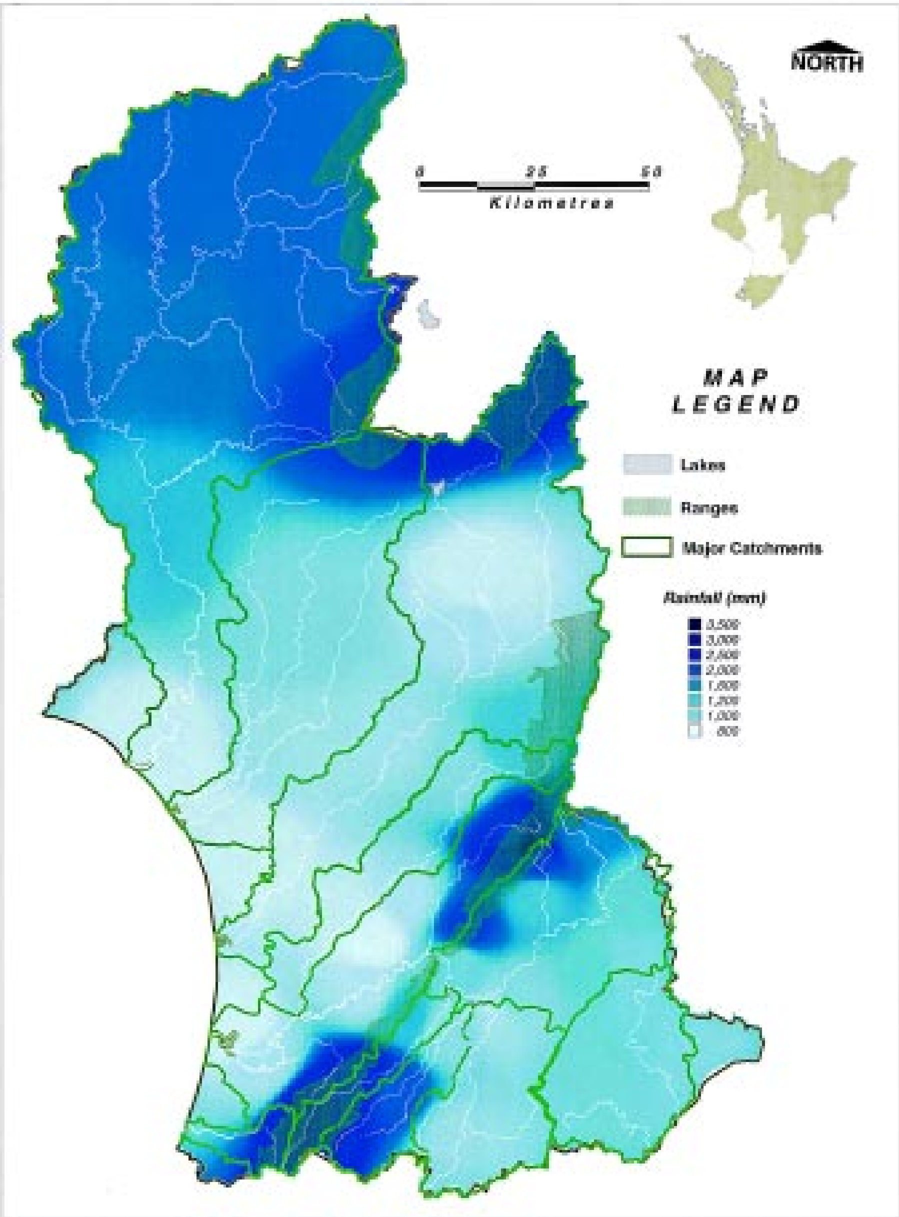
Water use is greatest where significant populations are located and where alluvial soils require irrigation of pasture or crops. Some water abstracted from the Ohau River serves an open water race providing rural water supply north of the river. Some is then returned to the Ohau River.

Most irrigation water is taken from the upper Manawatu River around Dannevirke. Many are small streams, under continued pressure from both abstraction and run-off as farming becomes increasingly intensive.

The Oroua River, mainly replenished by small headwaters in the Ruahine Range, is also under pressure. Its waters are needed for public supply, for pasture irrigation and for industry around Feilding. Below Feilding the river is constrained by stopbanks. Downstream of Awahuri there is virtually no natural inflow. Drainage schemes capture the river's natural runoff.

Nearly all the water needed to assimilate waste discharged from the Feilding area is sourced above Feilding. Abstractions therefore also have considerable impact on downstream discharge consents. Periods of

MAP 5: RAINFALL THROUGHOUT THE REGION



drought, severe in the east since November 1997, impact on the availability of quality surface water. With depleted river flows, water temperatures rise, less water is available to flush nutrients and growth, and to replenish ground water reserves. Some Ruahine rivers are so affected. The Akitio too, east of the divide on the Puketoi Range, was even harder hit by El Nino, creating shortages. Apart from decline in water volumes, immediate effects of drought are more in-stream algal growth, depleted in-stream oxygen levels and potentially fatal temperature stress on in-stream life. Longer-term effects include ground water depletion, with some significant socio-economic impacts.

RESOURCE AVAILABILITY (state)

RAINFALL

Rainfall, which determines how much water we have, is largely plentiful throughout the region (Map 5). However, on the east coast, and on the Rangitikei and Manawatu hinterlands, especially in recent years, rainfall is not always abundant in summer, leading to a proliferation of farm dams for stock water.

Nor is the pattern of rainfall in the ranges always consistent. Periods of drought may also occur at these higher altitudes though both range systems do not necessarily experience the same conditions at the same time. For example, some large flood events have occurred recently in rivers draining the Tararua Range while the upper Manawatu and Pohangina Rivers have declined to very low flows. Oscillations between significant prolonged periods of above or below average rainfall continue.

Prolonged above-average rainfalls increase the frequency of floods in rivers draining the ranges, increasing the rate of sediment movement and deposition of gravels. They raise the potential for river bank erosion and channel instability. Prolonged below-average rainfalls reduce flows, and the frequency and severity of flooding. Channels stabilise, riparian growth becomes better established and replenishment of downstream gravel supplies diminishes. It may be too that prolonged drought conditions in the ranges have contributed to forest canopy reduction.

FLOWS

In the Manawatu-Wanganui region few rivers and streams remain unmodified by humans. Most records of river and stream flow are from modified regimes, although in some cases records began prior to development. Mean river flows at representative locations throughout the region are in Map 6 showing modified flow regimes.

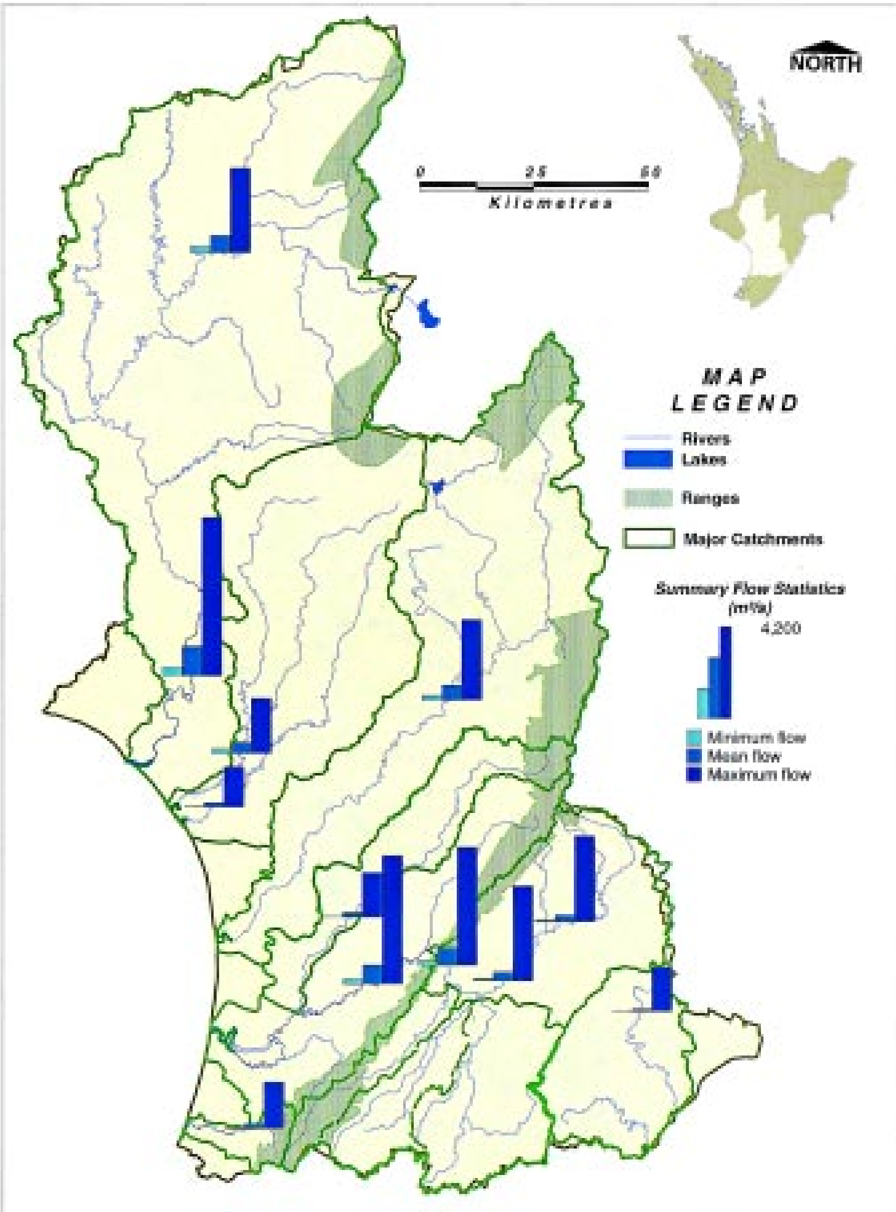
The Whanganui River, the region's largest in terms of catchment and flow, is integral to the lives of tangata whenua and highly valued for recreation. The status of the Whanganui National Park recognises the national significance of this river. The Manawatu is distinctive in that it is one of few rivers in the world to cross a main dividing range.

The Manawatu, Rangitikei and Whanganui Rivers have similar normal flow characteristics: higher flows in the winter months and low flows in February and March. Flood flows can be 30 times greater than normal flows. As a result of typically unsettled weather in December, the Manawatu River often experiences relatively high flows in early summer.

The Whakapapa River has been affected by the construction of the Tongariro Power Development, although the minimum flow provisions set by the High Court, effective since September 1992, have afforded some protection. However the natural regime of the river has been changed, with higher flows in summer than winter and spring. Extreme flood flows have not been affected by the Tongariro scheme because the intake structure at Whakapapa limits abstraction to a maximum of 42 m^3 per second.

Normal flow in the Ohau River rises from a late summer minimum, throughout the year until late spring. The largest floods in the Ohau have typically occurred in February and October. Its largest recorded flood is more than 100 times greater than normal winter flow.

The Akitio River is typical of mud-stone catchments in areas where



MAP 6: MEAN RIVER FLOWS AT REPRESENTATIVE LOCATIONS THROUGHOUT THE REGION

rainfall is less plentiful in summer. The normal flow range has a distinct winter peak; summer flows are small. Yields from these catchments are low. Extreme lows for the Akitio River at Weber are less then 10 litres per second; extreme flood flows may exceed 450,000 litres per second.

The Waitangi Stream, draining the volcanic plateau, demonstrates another kind of river character. Here rainfall is fairly evenly distributed throughout the year and the pumice and ash soils store large quantities of water. Flooding is rare and flood flows are as little as three to four times normal flow.


Mangatainoka River.

LIFE SUPPORTING CAPACITY OF AQUATIC SYSTEMS

The use of surface water tends to modify flow regimes. Modified flow regimes may affect aquatic ecosystems; in particular invertebrate and fish populations, and species diversity. Reducing flow abstractions can have a proportionally greater impact in summer. Reduced summer flows may result in:

- altered water depths and velocities that favour certain species
- higher water temperatures that adversely affect fish metabolism and exclude sensitive invertebrates such as mayflies
- reduction in available habitat area, reducing food supplies and limiting in-stream populations
- greater intrusion of nutrient rich ground water, promoting growth of algae.

Impoundments and diversions often reduce high flows, which act to 'cleanse' river systems. High flows slough algal growth from river beds and transport finer sediments long distances.

This issue is further defined and identified in the water quality, fluvial systems and ecosystems sections. horizons.mw has recently conducted fish habitat surveys in the Oroua River and its main tributaries and is currently surveying the upper Manawatu River. These results are not yet available.

CONTROLLING SCARCE WATER (response)

One mechanism to balance the water use while preserving its life-supporting capacity is to control water using resource consents and regional rules to ensure minimum flows necessary to support life.

Minimum flows for the Whakapapa and Whanganui Rivers were set following tribunal and court hearings. Current minimum flow provisions have been in effect since September 1992. Control points are set on the Whakapapa River near the intake and the Te Maire river gauge on the Whanganui River, both operated by the National Institute of Water and Atmospheric Research.

Minimum flow for the Whakapapa River has been set by court order at 3 m^3/s, or the natural flow of the river if less, all year. Minimum flow for the Whanganui River at Te Maire was set at 29 m^3/s, or the natural flow of the river if less, from 1 December each year to the next 31 May.

The natural flow of the Whakapapa River has never been known to fall below 3 m^3/s. Natural summer low flow is usually near 8 m^3/s. The natural flow of the Whanganui River at Te Maire often falls below 29 m^3/s during summer. To meet the minimum flow provisions, operators of the Tongariro Power Development scheme must occasionally cease all diversion and abstraction. In this way, briefly during most summers, the Whanganui River headwaters return to their natural state.

There is also a minimum flow requirement of 0.6 m^3/s for the Moawhangao River at Moawhangao Village. Current indications are that this flow is too little to maintain instream values in summer. The Tongariro Power Development resource consents renewal process is likely to result in Genesis Power agreeing to increase this minimum flow and also perhaps ensuring the river receives a flushing flow each spring.

horizons.mw has made rules in its Regional Plans under the Resource Management Act to control water takes, diverts and abstractions. While most are general in their application, rules in the Oroua Catchment Water Allocation and River Flows Regional Plan specifically address the water over-allocation problem, recognised for some time on this river. Minimum flow rules for the Oroua River and Kiwitea Stream were set to protect the life supporting capacity of the river's ecosystem. (However, the tradable water rights regime established by the Plan remains largely an academic exercise – since the Plan became operative in January 1995, only one permit has been traded.)

The 1998 plan change allowed for the effects of the major abstractor, Manawatu District Council, moving their abstraction point upstream of the river gauge. Both rivers have restrictions in place from November to April inclusive. Water allocation from the Oroua River is controlled by two levels of restrictions; the upper level varies monthly, the lower level remains the same throughout the controlled period, being set at the estimated natural average annual low flow. The Kiwitea Stream operates with only one restriction level, varied monthly.

The operators of the Mangahao Power Scheme are consented to flush silt from the reservoirs in the upper Mangahao catchment during annual maintenance periods. Flushing is carried out in late autumn. This avoids the summer recreational period, and maximises the potential for flood flows to quickly transport the silt through the lower river, preventing smothering of in-stream habitats.

SUMMARY

Our region is generally blessed with adequate surface water resources. Our larger rivers originate on the main divide or the central volcanoes, and generally receive ample rainfall to provide substantial flows over all but dry summer periods.

The greatest use of surface water in the region is for hydro electric power generation. Minimum flows protect the instream values of the Whakapapa and Whanganui Rivers. Consent renewal processes for these and other takes of water for the Tongariro Power Scheme may result in changed or additional minimum flow requirements in some other rivers and streams impacted by these diversions.

Demand for water for irrigation, and in some areas for domestic use, has increased over recent years. This puts pressure on some rivers during summer low flow periods when demand is greatest. Examples include the Oroua River near Feilding, tributaries of the Upper Manawatu River, and the Akitio River in the east of the Tararua District. Ongoing work is being carried out on what flows are necessary to maintain the life supporting capacity of these rivers and streams.

HOW GOOD IS IT? WATER QUALITY ISSUES

No matter how plentiful or pure it may be, as population and demand increase water is a resource that can never be taken for granted. For Manawatu-Wanganui, water quality issues are dominated by:

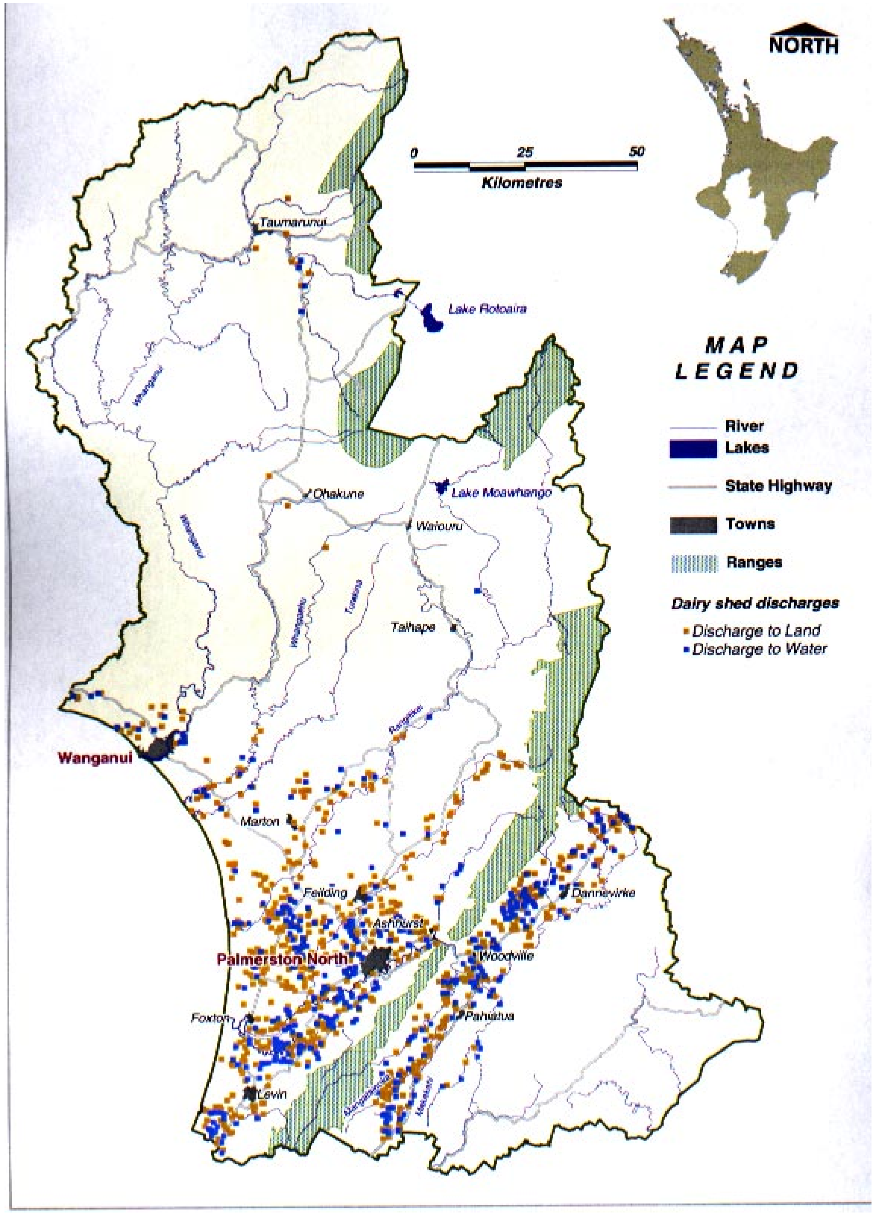
- health of aquatic ecosystems
- recreational and amenity value
- loss of utility of the water resource.

These issues are also related to various factors including water quantity, adjacent land-uses causing siltation, or point and non-point nutrient discharges that contribute to overall water quality. horizons.mw uses a range of measures to assess different aspects of the state of the region's rivers. Conditions good for one user group will not necessarily be suitable for another. For example, swimmers generally require higher standards of water quality than are needed to sustain fish life. A range of state parameters were selected to indicate these different aspects.

WATER QUALITY INDICATORS

- **PRESSURE**: number of resource consents issued for activities that may affect water quality
- **STATE**: Enterococci
  'Black disc' visibility
  Ammonia
  DRP (Dissolved Reactive Phosphorus)
  Dissolved oxygen
  Water temperature

MAP 7: DISCHARGES TO WATERWAYS



We track the indicators in several ways. horizons.mw keeps records of activities that can affect water quality in rivers, especially waste discharges. These provide a useful indicator of some of the pressures on the region's surface waters. It also monitors a range of water quality parameters in rivers throughout the region, shown later in this section. (Some rivers are also monitored by National Institute of Water and Atmospheric Research, as part of the National Rivers Network and some of these data are also used in this report.)

PRESSURES ON OUR WATERWAYS – RESOURCE CONSENTS ISSUED (pressure)

DAIRY SHED WASTE DISCHARGES

As a highly productive agricultural region, with large areas of dairying, pastoral and cropping land there are pressures on our river, lake and wetland environments.

Agriculture-based processing activities such as dairying, meatworks and tanneries produce concentrated waste discharges that require disposal. horizon.mw's consent processes regulate these discharges. Dairy milking operations are particularly significant in parts of the region.

- 1220 dairy shed waste discharges
- 75 percent of these are in the Manawatu River catchment
- one-third of dairy shed waste discharges are to rivers, streams and drains – two-thirds disposed to land
- coastal lake catchments receive only 2.5 percent of the region's dairy shed waste discharges, and most of these wastes are disposed to land. However, because the lake catchments are small, they have the highest *density* of dairy shed waste discharges (number of discharges per area of land) after the Manawatu River catchment.

Three-quarters of the region's total dairy shed discharges are within the Manawatu Catchment. There are a small number in the region's coastal lake catchments. But because the area of these catchments is small, the number of dairyshed discharges per square kilometre in some coastal lake catchments is, after the Manawatu catchment, second highest. However, a high proportion of the discharges within coastal lake catchments (90 percent) are disposed to land (Figure 11).

The proportion of dairysheds that discharged finally to water following treatment in ponds has declined significantly in the Manawatu Catchment over the last six years. In late 1992, 48 percent of dairysheds in the catchment discharged to water. By June 1997 that proportion had decreased to 43 percent and by January 1999 to 36 percent.

AGRICULTURAL LAND USE

Even without speciic source discharges from dairy sheds or agricultural industries, general agricultural land use can still degrade water quality in our waterways (see Ground water section). Contaminants such as sediment, bacteria and nutrients are washed off the land into rivers during rainfall. Direct livestock access to streams can also degrade water quality, affecting stream life, but how and to what extent is still poorly understood.

Another profoundly important issue is stream shading provided by trees. Modification of habitat removes protective cover for fish, destabilises stream beds and banks, making streams vulnerable to high temperatures. horizons.mw conducts some limited temperature monitoring, presented in this report. However, related physical variables, and the stream life itself, have not been widely monitored. In order to assess these variables for a future State of Environment Report we are now monitoring physical variables, stream life and temperature.

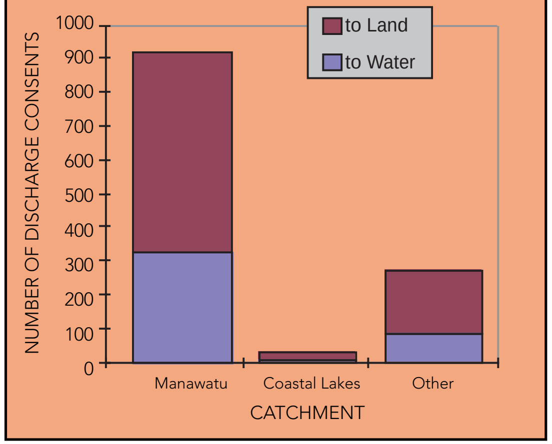

Dairying contributes greatly to the economic well-being of the region. The challenge is to contain its effluents.

CLEANING UP: SEWAGE WASTE DISCHARGES (pressure)

Manawatu-Wanganui region's human population also exerts direct pressures on our waterways through the disposal of sewage waste. The location of sewage waste discharges in the region is shown in Map 7.

Most high volumes of sewage requiring disposal are generated by medium-large urban centre populations. However, there are many smaller communities throughout the region also producing treated sewage waste discharged to rivers, streams or drains.

FIGURE 11: Number of dairyshed waste discharges in the Manawatu-Wanganui region

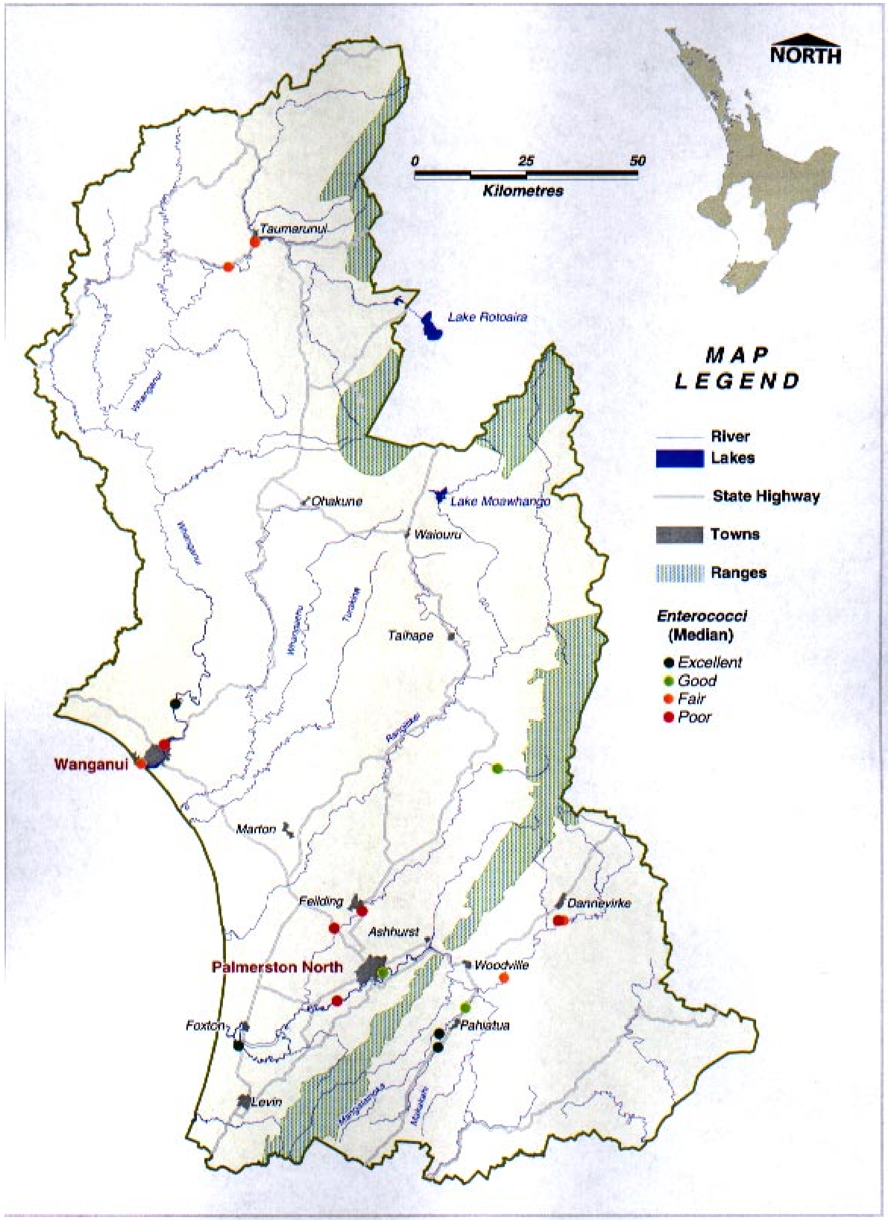


SEWAGE DISCHARGES: THE FACTS

- There are 44 community sewage discharges in the region, 39 of which discharge to rivers, streams and drains, one to the ocean. Only four sewage discharges are disposed to land.
- Of the 40 discharges to water, 20 are in the Manawatu catchment, seven in the Rangitikei River catchment, six in the Whanganui River catchment, and four in the upper Mangawhero-Whangaehu River catchments.

The number of sewage waste discharges by catchment are shown in Figure 12. The Manawatu stands out. Note that, unlike dairyshed waste discharges, nearly all sewage discharges are disposed to our waterways – only a handful are regularly disposed to land.

MAP 8:
ENTEROCOCCI LEVELS



STATE OF OUR RIVERS

We use a range of different indicators to identify the different issues relevant to the different uses and demands put on our rivers.

Issue	*Indicator*
Disease risk to humans during recreational use	Enterococci
Water clarity	'Black Disc' visibility
Toxicity to stream life such as fish	Ammonia
Excessive growths of green algal slime	DRP (Dissolved Reactive Phosphorus)
Life supporting capacity for stream life	Dissolved oxygen
Life supporting capacity for stream life	Water temperature

Data for each indicator is summarised in Maps 8 to 11 and Figure 13. Data for the five-year period from mid-1993 to mid-1998 is used, except where otherwise noted. Note that the data is selected for *low river flows*, because that is when poor water quality is of greatest concern for recreational use and stream life.

HOW SAFE ARE OUR RIVERS FOR SWIMMING? (state)

Council monitors levels of an organism called "*enterococci*", which commonly co-exists with disease-causing organisms in water. Monitoring *enterococci* levels in our rivers therefore helps assess disease risk to people engaging in recreational activities, particularly swimming.

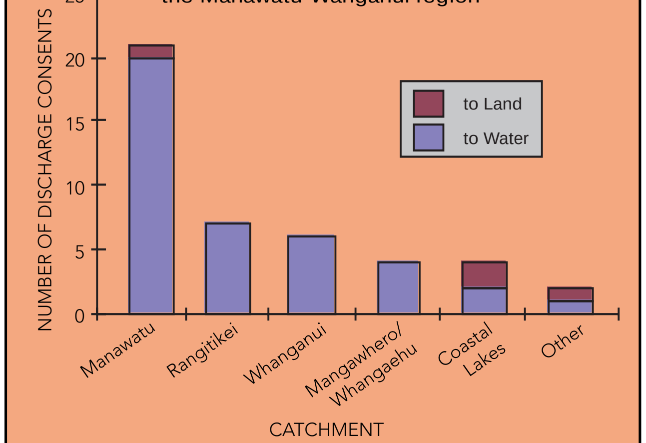
Enterococci levels are summarised in Map 8. The levels are based on Ministry of Health guidelines, and indicate the suitability of the rivers for contact recreation such as swimming. These are not related to suitability of water for drinking. Note that these levels apply at *low river flows* that generally occur during the warmer weather of summer and autumn – a time when contact recreation in the region's rivers is common. By contrast, *enterococci* levels are characteristically highest when river flows are highest. But people are not usually placed at high risk because such activities as swimming are rarely undertaken at such times.

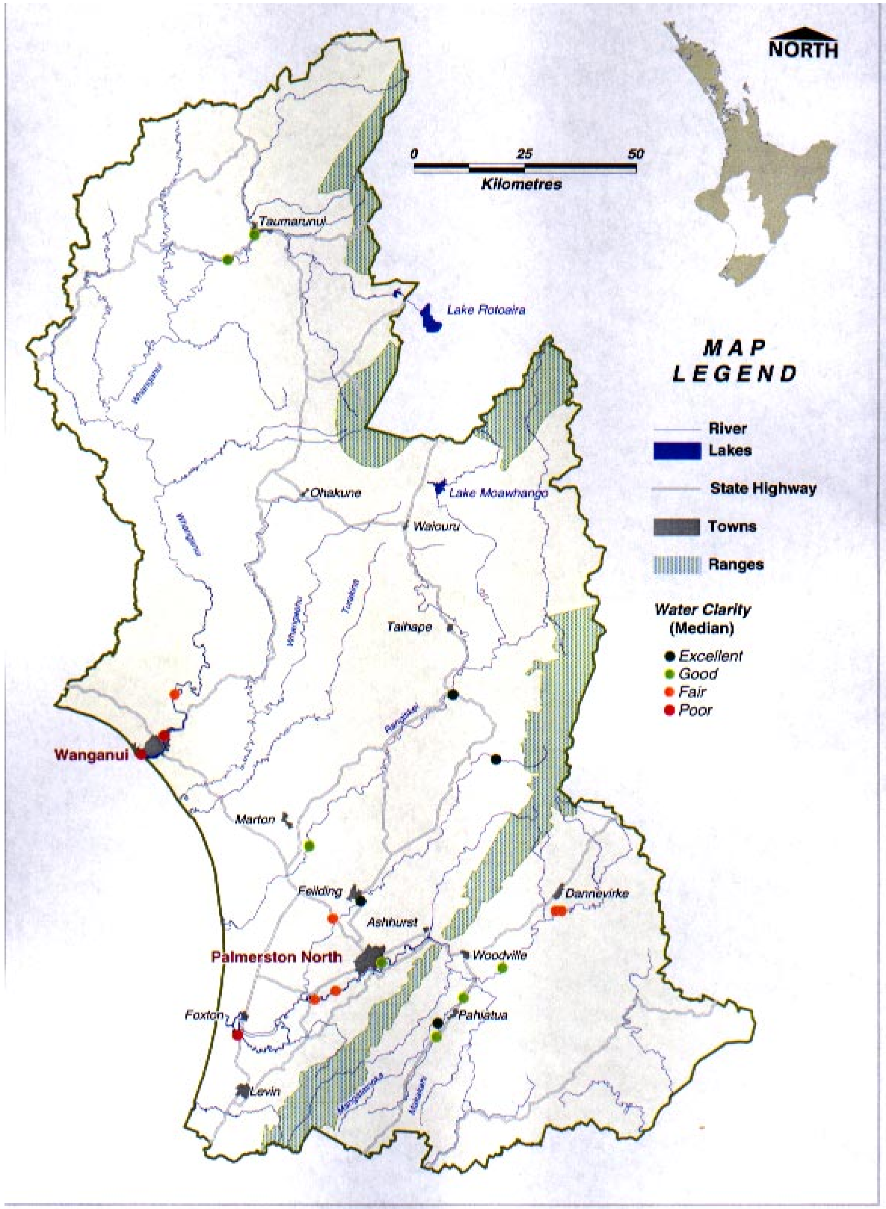
Map 8 shows that the disease risk to people swimming in our rivers varies greatly among sites throughout the Manawatu-Wanganui Region. Many of the sites with highest disease risk are located below major sewage discharges. These sites include: the Manawatu downstream of Palmerston North; the Oroua River near Feilding; the Mangatera downstream of Dannevirke; and the lower Whanganui River near Wanganui.

Over the past year, sewage from Wanganui has been diverted to an ocean outfall. Latest data are showing the beginnings of considerable improvement from the situation depicted in Map 8. Remaining discharges will need to comply with enterococci standards in the Manawatu Catchment Water Quality Regional Plan by the year 2004.

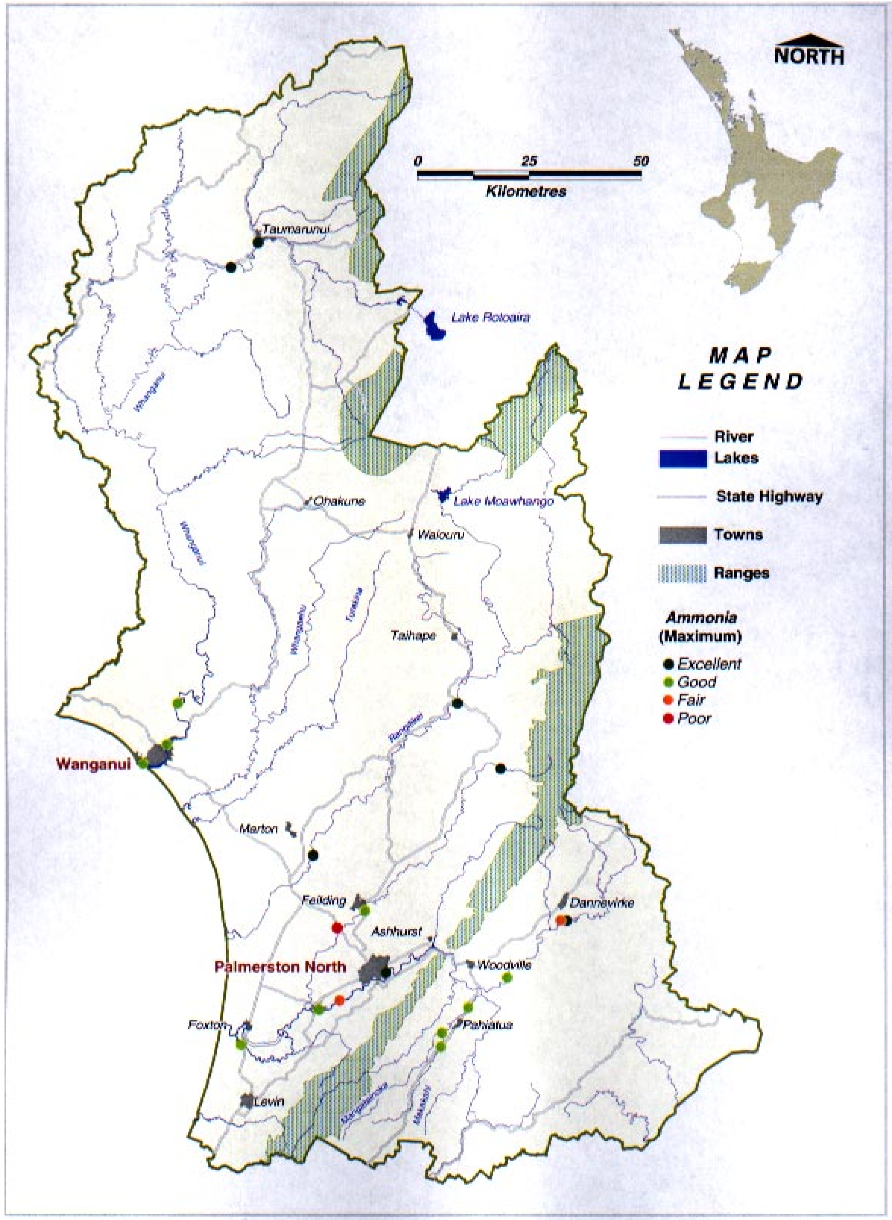
There are a number of sites where health guidelines are exceeded but where there are no specific-source-discharges such as sewage. These sites include the Whanganui and Ongarue Rivers at Taumarunui, the Manawatu River upstream of Dannevirke, and the Oroua River upstream of Feilding. In these cases the specific cause of contamination is unknown. It may be by seepage of animal waste from pastures, seepage from septic tanks,

FIGURE 12: Number of sewage discharges in the Manawatu-Wanganui region





MAP 9: WATER CLARITY



MAP 10: AMMONIA LEVELS

livestock wading and defecating directly in streams, or livestock eroding banks which collapse into waterways. Further investigation is needed.

Recent concerns have been raised about levels of other microbial contaminants such as Giardia and Cryptosporidium in rivers in the Waikato and Canterbury regions. horizons.mw has little information on these in our region at the present time.

HOW CLEAR IS OUR RIVER WATER? (state)

horizons.mw monitors water clarity using a method called "black disc visibility". This is a measure of how far away objects (in this case, a black disc) can be seen through the water.

Typical black disc visibilities (at low flows) are summarised in Map 9. Clarity in our rivers is generally good at low flows, especially in the upper and middle reaches of our river catchments. Sites that have only fair clarity are those affected by major discharges. The sites with poorest clarity appear to be affected by natural factors, in particular the slow-flowing lower reaches of the Whanganui and Manawatu Rivers. However, another factor could be the discharge of historical erosion sediment accumulated over many decades.

STREAM LIFE AND TOXICITY (state)

Council monitors concentrations of "ammonia" in the region's rivers. Ammonia is a common pollutant in organic waste discharges such as sewage, dairy shed and meatworks discharges. Where present in high concentrations, ammonia is toxic to such stream life as fish and invertebrates.

Ammonia levels, summarised in Map 10, show that ammonia levels are not a widespread problem for stream life. Again, some problems exist below major sewage discharges, in particular the Feilding sewage discharge in the Oroua River. While ammonia readily breaks down in the natural environment, strong discharges can inhibit fish migration upstream to less-polluted reaches.

GREEN ALGAL SLIMES (state)

Excessive growths of green algal slimes are undesirable because they are slippery and unpleasant for swimmers and waders, and degrade riverbed habitat for stream life. Where levels are high, as they were in the Manawatu in the 1970s-80s, they can deplete oxygen levels in the water overnight, threatening survival of stream life such as fish.

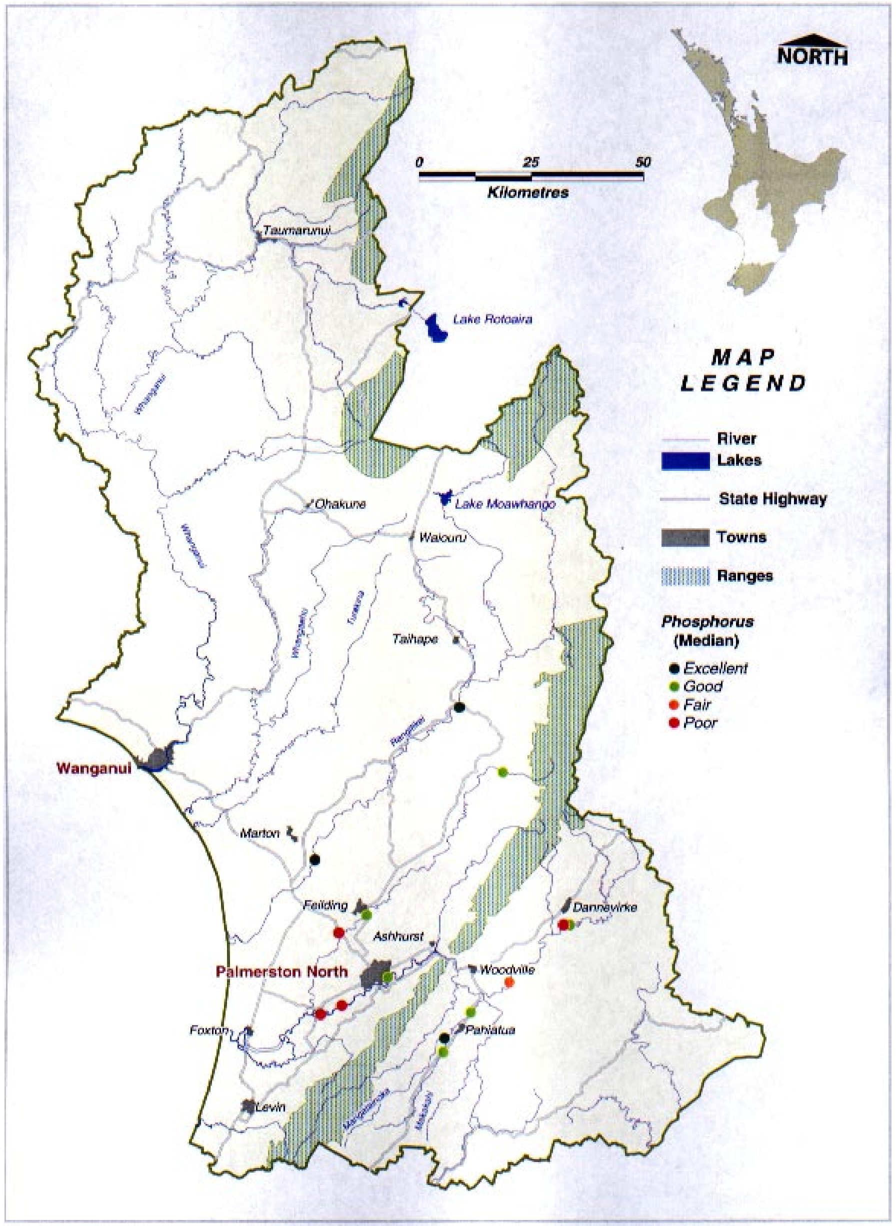
In the absence of detailed monitoring of the presence and severity of algae covering riverbeds the council measures nutrient levels. These are an indicator of the degree of enrichment of streams, and hence the potential for excessive algal growth to degrade the stream bed. Levels of soluble phosphorus, called "dissolved reactive phosphorus" or "DRP", are a good indicator of the potential for algal slimes to reach excessive levels during low flows in the Manawatu and probably the Rangitikei rivers.

These levels apply at *low river flows* which generally occur during summer and autumn. This is when warmer weather occurs – the time when contact recreation in the region's rivers is common, and when other conditions also favour growth of nuisance algae.

We can see that DRP levels are generally good-to-excellent throughout much of the Manawatu and Rangitikei catchments (Map 10). The few sites where nutrient levels are high are invariably downstream of large specific source discharges such as sewage. This contributes to intensive algal growth during low flows.

ARE OXYGEN LEVELS ENOUGH FOR STREAM LIFE? (state)

Oxygen is as basic a requirement for stream life, as is water to our waterways. Oxygen gas is soluble in water, and dissolved oxygen levels are a fundamental indicator of life supporting capacity in rivers and streams. These are measured regularly at most horizons.mw monitoring sites throughout the region. Monitoring indicates that most of our river sites have sufficient oxygen to support stream life. In Figure 13 dissolved oxygen levels at three sites, two of them badly affected, in the Manawatu River are illustrated.



MAP 11: PHOSPHORUS LEVELS

We can see that oxygen levels fluctuate seasonally at all sites, with higher levels in winter and lower levels in summer. At Ruahine Street (upstream of Palmerston North) these fluctuations are well within limits required to support stream life. Tellingly, at Karere Road (a site several kilometres downstream of Palmerston North) summer oxygen levels are just within limits for supporting life. High levels of algal growth and, at times, sewage fungus, are measured on the riverbed at Karere Road during summer. These growths are caused by a combination of waste discharges, mainly sewage from Palmerston North and effluent from the milk processing factory at Longburn. However, for more than a year now during low flows the milk factory has been disposing mostly to land. Sewage fungus growth has now gone as a result. (See page 16.)

At Foxton Loop, oxygen depletion occurs over summer because of dieback of dense aquatic weed beds. The still backwaters of the Foxton Loop, flushed only by gentle tidal action, are a haven for such weed growth. As the weed beds rot, they consume oxygen. At these times the oxygen levels at the Foxton Loop are below those considered healthy for survival of some fish species.

FIGURE 13: Oxygen levels in water at Manawatu River sites

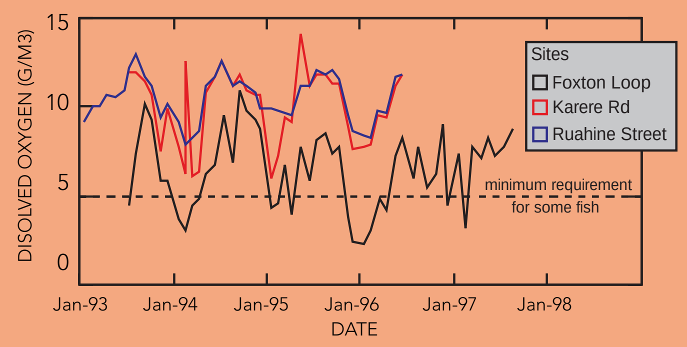
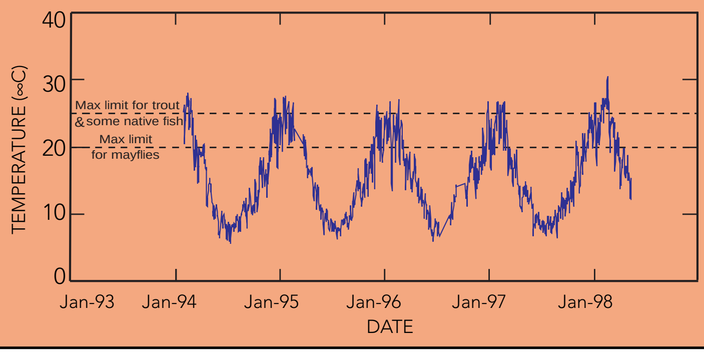


FIGURE 14: Daily maximum temperature for the Oroua River at Almadale



Dissolved oxygen levels in water vary not only seasonally, but daily. Usually the lowest oxygen levels occur around dawn. Because horizons.mw monitoring doesn't measure oxygen levels at dawn, the actual situation may be worse than indicated in Figure 13. horizons.mw has recently purchased equipment enabling 24-hour monitoring of oxygen levels at selected sites.

WATERS COOL ENOUGH FOR FISH (state)

If water becomes too warm, many of our native and introduced fish can become stressed, stop feeding, thereby losing condition, or become susceptible to diseases. Since many of our streams are wide and shallow they are also vulnerable to temperature increase. When the frequent lack of tree shade along banks in our farmlands is added to the mix, the smaller streams, in particular, experience high temperatures on summer days. Reducing stream flow for town water supplies or irrigation, can also add another pressure, making streams vulnerable to temperature increase.

Figure 14 shows daily maximum temperatures recorded at Almadale on the Oroua River. Limited historical data show that the Oroua River experiences temperatures unsuitable for some sensitive invertebrates such as mayflies. Trout and some native fish may also be affected.

The significant issue for the Oroua River is that, for most of the 1994-98 period, there are significant pressures downstream of Almadale. Water abstractions for irrigators and, until mid-1997, the Feilding water supply, probably produce even higher temperatures downstream than those shown in Figure 14.

The effect of downstream waste discharges (such as the sewage from Feilding) on stream life would also be compounded by elevated water temperatures. Ammonia is more toxic to fish at higher water temperatures and we know (Map 10) that downstream of the Feilding sewage discharge the Oroua experiences high ammonia levels.

Temperature monitoring will therefore be a vital component of the council's stream and river monitoring programmes in the future.

BATTERY ACID RIVER – NATURALLY!

Nearly all our measurements exclude one special river, the natural condition of which can make any pollution seem very mild. The Whangaehu River, which drains from the Crater Lake of Mt Ruapehu, has naturally very acidic water which greatly limit its ecological and other values. At Karioi on State Highway 4, horizons.mw has measured water with a pH as low as 1.8, on par with battery acid. Not surprisingly, the river there is biologically dead. Even at the State Highway 3 bridge, about 10 km from the river mouth, the pH can fall as low as 3.6.

CONCLUSION

The quality of our surface waters is highly variable. Quality generally declines as one moves down a river. This decline is usually most marked in two ways. Water clarity declines due to slower velocities and high levels of suspended sediment. The level of microbial contamination increases, making the water in many of our rivers less safe for swimming at low flows.

The most marked influence on water quality is often discharges of treated sewage to water. Prominent examples are the discharges from Palmerston North and Feilding into the Manawatu and Oroua rivers respectively. Both result in increases in microbial contamination. Feilding's discharge raises levels of the toxin ammonia to high levels, and the Palmerston North discharge elevates phosphate levels, and growths of algal slime during low flow periods, to high levels.

Even without the effects of these specific source discharges, elevated levels of microbial contamination are of concern in many rivers around the region. These include the Oroua River upstream of Feilding, and the Ongarue River near Taumarunui.

PROTECTING THE AQUIFERS: THE STATE OF GROUND WATER

Since ground water is a vital source of water for agriculture, cropping and direct human use, its protection is crucial. Drawing from run-off from the main divide and the alluvial plains, ground water (water stored naturally in the ground) is used in the Manawatu-Wanganui region from an estimated 12,000 bores (Map 12). Like all resources, its supply is not infinite.

Ground water is less vulnerable to contamination than surface water, and less subject to seasonal fluctuations. Ground water is thus a more reliable source. By October 1998, 357 water permits were issued to take up to 310,000 m^3/day of ground water in the region. By comparison, there were 185 takes from surface water with a maximum take of 257,000 m^3/day.

For rural areas, particularly in the Tararua, Horowhenua, and Manawatu Districts, ground water is the main source of drinking water. For Foxton and Wanganui it is the predominant source of drinking water. It contributes significantly to the water supplies of Palmerston North, Feilding, and Marton. The number of permits and quantity of ground water taken is increasing and now exceeds takes of surface water.

ISSUES

We identified the following issues for the ground water programme:

- decline of ground water levels from depletion of aquifers resulting from excessive irrigation or artesian water flowing uncontrolled from bores
- decline of ground water quality resulting from both natural hydrological processes and human impacts. ("Natural hydrological processes" refers to instances of natural concentrations of minerals, such as iron and manganese, exceeding drinking water standards, or guidelines in some parts of the region.)

These two issues are intimately associated. For example, changing ground water levels can initiate undesired changes in ground water quality.

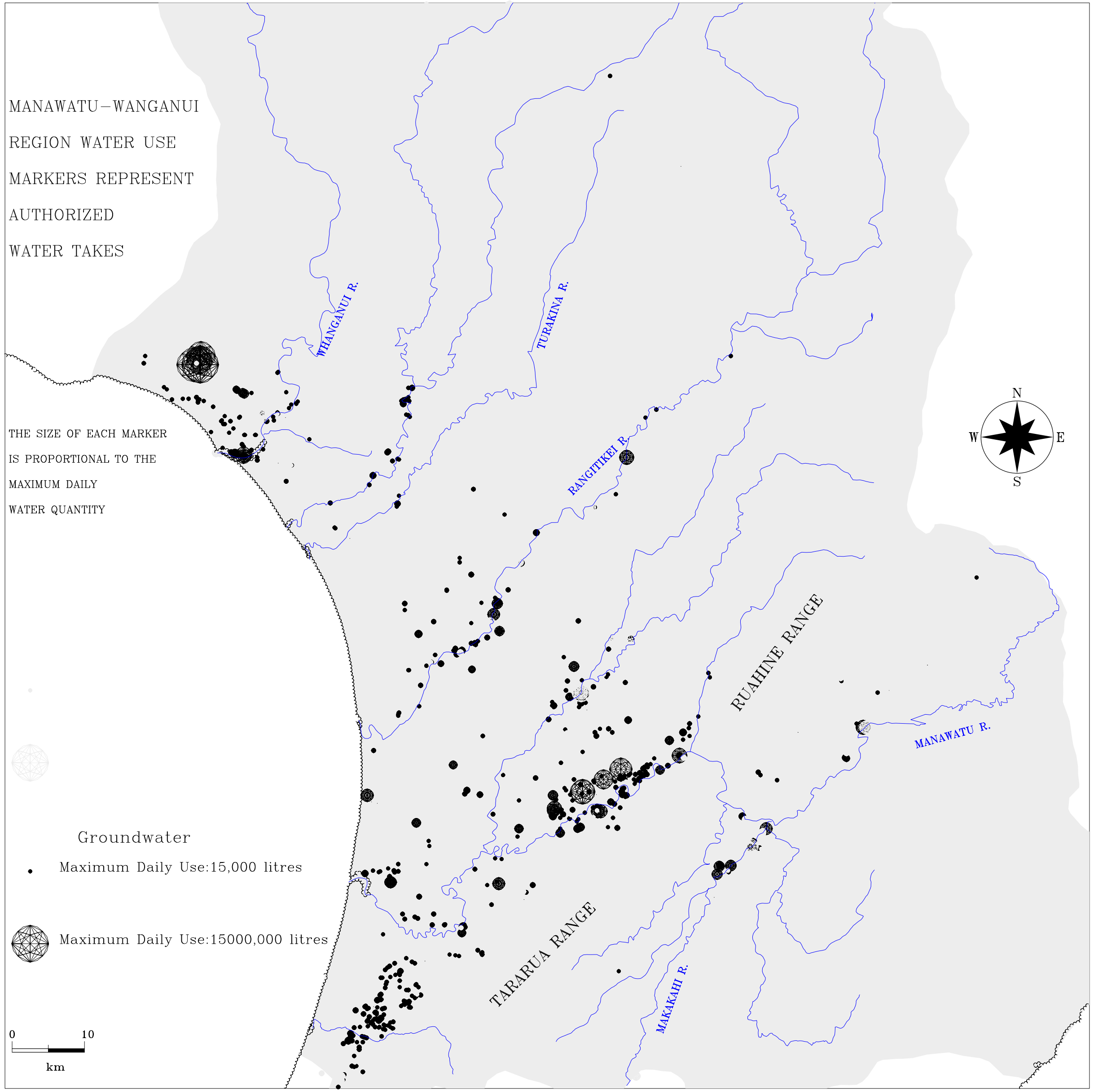
GROUND WATER LEVEL (state)

Ground water level is the single state indicator for ground water quantity. Also known as static water level in a bore changes, this changes over time

GROUND WATER INDICATORS

- PRESSURE:
  Number of resource consents (not reported)
- STATE:
  Ground water level
  Major cations and anions
  Turbidity .ph
  Nitrate-nitrogen
  conductivity
  Biocides

MAP 12: THE STATE OF GROUND WATER



and seasons. The static water level (the 'ground water level') changes from site to site as well as over time. At a given site, the static water level for deep ground water can even be different to that of shallow ground water.

Fundamentally these levels are influenced by the amount of recharge (from rainfall and surface waters), ground water use, and discharge (to surface water bodies, including the sea). Declining ground water levels may therefore indicate natural hydrological processes as well as effects of excessive, unsustainable, ground water abstractions and changes in the land drainage system. Increasing ground water levels may indicate higher than normal rainfall recharge or changes in the land drainage system.

horizons.mw monitors ground water levels monthly at 150 bores throughout the region. These are concentrated in areas of high ground water use or where trends in ground water levels are of concern. Examples include around Whakarongo, Feilding and the Horowhenua. In the majority of bores, ground water levels are stable since 1991, when the present monitoring network was established. The ground water monitoring network was designed to cover areas where a significant amount of ground water is used and to concentrate on environmental concerns. Ground water level is monitored in about 150 bores throughout the region at monthly intervals. In addition, 15 sites are equipped with automatic monitoring devices yielding measurements at 15-minute intervals.

Few records are available with more than 20 years of data. Figures 15 and 16 show ground water levels for artesian bores in Palmerston North. At site 335313 ground water level declined in the early 1980's but recovered by 1992. At site 336001, however, the ground water level has declined about one meter and stabilised on a new, but lower level (Figure 16).

In Whakarongo, between Ashhurst and Palmerston North, ground water is used extensively for municipal and individual water supply, market gardening, horticulture and stock purposes. Because of increased use of ground water (Bekesi, 1991) the ground water level has declined through the 1980s in artesian bores of medium depth. As Figure 17 indicates, this ground water has not since recovered and stabilised on a new and lower level.

Although no continuous long term data are available for Whakarongo, the hydrograph in Figure 17 shows a similar trend to that of Figure 16. Since 1988 ground water levels have been stable.

It is important to note that these long term hydrographs are obtained from *confined* or artesian aquifers. Such aquifers occur normally at greater depths than unconfined aquifers. The water storage capacity of confined aquifers is small (10^{-4}-10^{-5}) by comparison with unconfined aquifers (10^{-1}). The ground water level in confined aquifers can therefore change rapidly. If such confined ground water levels decline because of over-abstraction they may decline very rapidly until they reach a new equilibrium at a lower ground water level as in Figure 17.

Since the early 1990s ground water levels south of Feilding have declined. This is probably due to increased water use in the area, although historical data does not exist on water use in the region. Figure 18 shows the slow decline of ground water level and the impact of a significant ground water abstraction close to the monitoring site. Occasionally ground water use was terminated in a nearby industry for a short period, so the resultant peaks show where natural ground water level would normally be.

The decline of ground water level near Feilding cannot be explained by a decrease in rainfall recharge further up in the catchment (Most of Feilding ground water is recharged at higher altitude areas north-east of Feilding.) Therefore an increase in surface and ground water use appears to be the most likely cause of the decline. As no data are available on historical water use, such a relationship cannot be illustrated.

FIGURE 15: Ground water level at Pitama Road, Palmerston North, site 335331

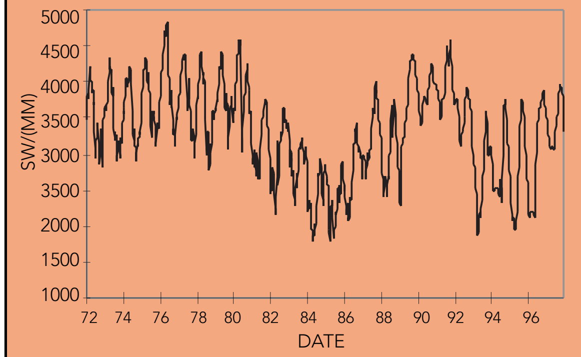
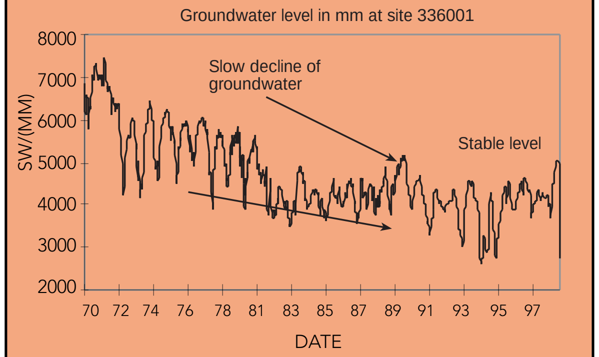


FIGURE 16: Ground water level at site 336001, Milson airport



In future, ground water levels south of Feilding will either stabilise on a new and low level, or continue to decline. In the latter case horizons.mw may have to limit ground water use locally.

Ground water levels have generally remained stable in the Manawatu, Horowhenua, and Tararua Districts since 1991. Ground water levels have risen in deep, confined aquifers in Wanganui and east of Wanganui.

FIGURE 17: Ground water level at site 336421, Whakarongo

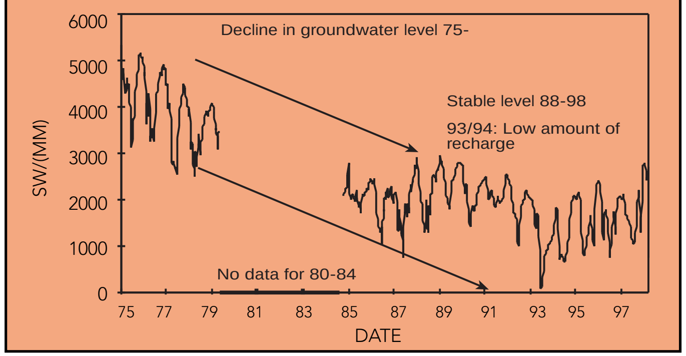
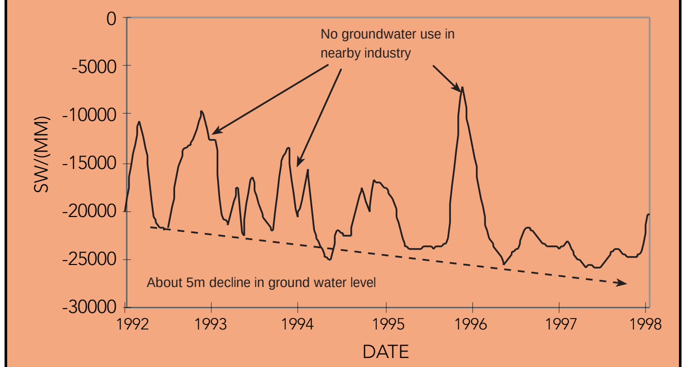


FIGURE 18: Ground water level in a bore south of Feilding, site 325019. The arrow indicates a declining trend.



CONCLUSION

In general, ground water levels are stable in the region because there is adequate rainfall to recharge ground water. In some areas, however, ground water level has changed either permanently or seasonally. As a result, there is increasing pressure on the ground water resources east of Palmerston North (Whakarongo) and in Feilding.

GROUND WATER QUALITY

MEASURES OF GROUND WATER QUALITY (state)

Ultimately, no matter what its level, water's usefulness is limited by its quality. Indeed, the increasing use, and diversity, of potential ground water contaminants in the region has recently shifted the focus of ground water investigations, moving it from levels to quality and contamination issues.

To monitor the suitability of ground water for drinking and other uses several key indicators were identified. Major ions, known as **cations** and **anions**, indicate the presence of key solids in water. Cations include: calcium, magnesium, sodium, potassium, iron, and manganese. Anions include: alkalinity, chloride, sulphate, nitrate, nitrite, ammoniacal nitrogen, and dissolved reactive phosphorus. These measure the amounts of solids present in water.

Turbidity measures the presence of fine suspended solids in water. **pH** directly influences the solubility of major ions and their chemical reactions. **Nitrate-nitrogen** is a high priority indicator for contamination. Faecal contamination from any warm-blooded animal is indicated by the presence of faecal coliforms in ground water. **Conductivity** reflects the ability of a solution to conduct electrical current. **Biocides**, pesticides, herbicides and insecticides can leach through the soil and reach the ground water system.

We currently monitor water quality in 30 bores once every six months, as well as many one-off samples for nitrates.

MAJOR CATIONS AND ANIONS

Ground water quality varies from place to place and depending on the depth of the aquifer. Shallow ground water in the Horowhenua area is contaminated by high levels of nitrate-nitrogen posing a health hazard to rural residents who drink such water.

Most of the deep, confined ground waters in the Wanganui District and around Palmerston North meet the drinking water quality standards.

Deep ground water in the Rangitikei and Manawatu Districts has naturally high iron, and manganese concentrations that are in excess of the MAV of the NZ drinking water standard (Ministry of Health, 1995). Iron is one of the most abundant cations in soil, rocks and minerals. The New Zealand guideline value for iron, as an aesthetic determinant is 0.2 mg/l. Natural iron levels of ground water exceed the guideline in some places in these districts. Excessive iron concentration gives water rust brown appearance, bad taste, staining of laundry and irrigation system blockages.

Evidence of manganese neurotoxicity has been observed and is the reason for the provisional MAV. Similarly to iron, manganese can stain laundry and sanitary ware. Iron levels can be high (depending on the bore depth) almost anywhere in the region. The only exception is the Palmerston North-Whakarongo area where iron levels are moderate or low for most bores.

In addition, deep ground water is high in hardness (calcium and magnesium) in the Rangitikei District. Ground water with high total hardness causes scale and scum formation.

BIOCIDES

The use of pesticides, including herbicides and insecticides, or man-made organic compounds, has increased in the last few decades and traces of these compounds have been found in ground water world-wide. Because of the toxicity and health risks of pesticides in drinking water this is an issue.

Data are available from reconnaissance pesticides surveys since 1994. At present 64 analyses are available for 57 bores in the Manawatu, Tararua, and Horowhenua areas. All analyses measure pesticide and herbicide concentrations down to levels of less than one part per billion.

No pesticides were detected in any of the Manawatu and Tararua samples. Bromacil was detected in two Horowhenua bores. In addition oxadiazon was found in another bore in the Horowhenua district. Both bromacil and oxadiazon are medium to long term herbicides. The detected levels are orders of magnitude smaller than Australian or USA standards. Based on the 1994, 1996 and 1997 surveys, pesticide levels in ground water in the region are either below detection limits or very low. Ongoing monitoring of pesticides in ground water will continue.

Artesian bore, Longburn.

CONCLUSION

Ground water quality varies from place to place in the region and with the depth of the aquifer. Most of the deep, confined ground waters in the Wanganui District and around Palmerston North meet the drinking water quality standards.

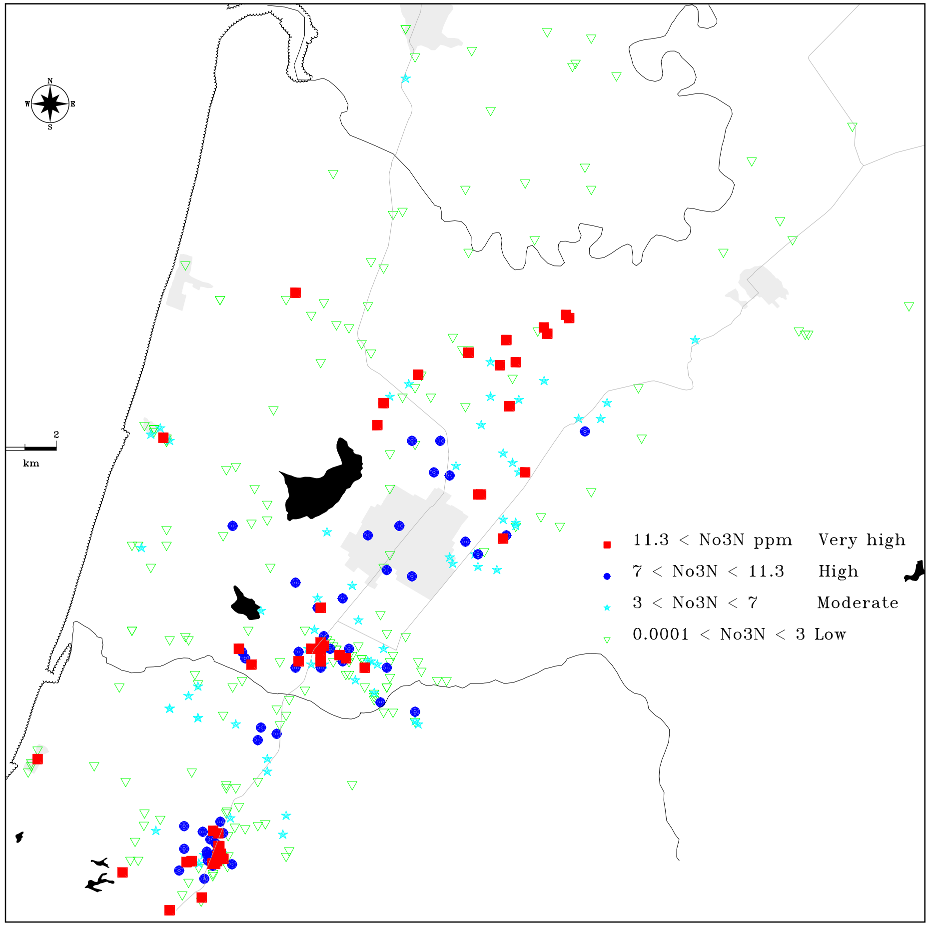
Deep ground water in the Rangitikei and Manawatu Districts contains naturally high iron, and manganese concentrations that exceed the MAV (Maximum Allowable Value) of the New Zealand drinking water standard (Ministry of Health, 1995). High iron and manganese levels are present also in some shallow Tararua, and deep Horowhenua ground water.

High nitrate levels in most Horowhenua, and some Tararua ground waters pose a health risk for the rural population who depend on ground water as their main and sometimes sole source of drinking water. Elevated nitrate levels are most likely caused by intensive land use. Encouragingly there are virtually no traces of pesticides in any bore tested to date.

Case study: Nitrate contamination of shallow ground water

The New Zealand guideline value for nitrate, as a determinant of health significance is 11.3 mg/l as NO_3-N. In the Manawatu Wanganui region, nitrate concentrations of ground water exceed the maximum acceptable value in a large number of bores in Horowhenua and in some bores in the Tararua District. Nitrate-nitrogen is considered a broad indicator of contamination of

MAP 13: NITRATE CONCENTRATIONS IN THE HOROWHENUA GROUNDWATER BORES



ground water from a variety of sources, including fertilisers, agricultural and human wastes.

Nitrate is considered to be toxic in water in excessive concentrations. The most significant health implication of excessive nitrate in water is a condition known as blue baby syndrome in bottle-fed infants. Nitrosamines may also arise as products from consumption of nitrates. High levels in water and diet have been linked to some type of cancers.

Nitrate levels exceed the New Zealand drinking water standard in about a quarter of Horowhenua bores (Bekesi, 1996). Nitrate concentrations are high in the Manakau, Ohau, and Lake Horowhenua-Koputara areas and in some beach settlements of the Horowhenua District (Map 13).

Statistical and spatial simulations indicate that if all inland Horowhenua bores were sampled, about 20 percent of the shallow ones used for drinking water would exceed the drinking standard nitrate levels. More than one-third of all bores are predicted to have elevated (above 7 mg/l) nitrate levels and two-thirds of all shallow inland Horowhenua bores are predicted to have non-natural, or elevated levels of nitrate-nitrogen.

There is no further increase since 1996 in nitrate in bores with high nitrate-nitrogen concentrations. There appears, however, to be a significant increase in nitrate over the last ten or twenty years in some bores that originally had low levels of nitrate. For example, nitrate levels have increased from 0.6 to above 4 mg/l in bore 363112.

The widespread nature of contaminated bores – a slowly increasing trend – indicates diffuse sources, in addition to use of septic tanks, associated with land use. There is therefore a potential for further degradation of ground water quality in Horowhenua. The indicator work of horizons.mw is designed to alert us to such trends.

NOT A MAJOR CONCERN: HAZARDOUS WASTES

Hazardous wastes signify the amount of hazardous wastes we generate and the effect that their disposal can have on human and environmental health. However, limited information is available on disposing hazardous wastes in the Manawatu-Wanganui region.

A survey was undertaken in 1992 on the types, quantities and disposal methods of hazardous wastes generated by the industrial and commercial sectors in the region. The survey was incorporated in a report 'Regional Policy Review of Hazardous Wastes', undertaken in August 1998. Results indicated 145,000 m^3 per month of hazardous wastes were generated. The majority of wastes were in liquid form (99.7 percent) and were discharged as trade-waste into sewage systems for treatment. The remaining 0.3 percent comprised solid wastes. No attempt was made to estimate the solid mass loading of hazardous wastes within the liquid stream. After scale-up, the total amount of hazardous wastes generated in the region was estimated to be of the order 198,000 m^3 per month.

The most common method of disposal was via release into water bodies, primarily rivers, storm water and sewerage drains (69 percent). The second most common method of disposal was land treatment or biodegradation of liquid or sludge discards in soil (22 percent). Landfills accounted for the disposal of only one percent of total hazardous wastes (5940 tonnes per year). About 8 percent of hazardous wastes were disposed by 'other' means including: return to manufacturer; give away to other potential users; give to a waste contractor to dispose; and, where no disposal options are available, storage.

Palmerston North gas works (gassometres round circles)

FINDINGS

Little information exists on the actual effects of hazardous waste on the environment in the region. Water quality monitoring data for specific point-source liquid discharges and landfills in the region are discussed above. However, at this stage monitoring programmes for water quality are more designed to capture general information about water quality rather than to collect specific information on chemical contamination. Even though many chemicals, such as heavy metals, have a tendency to accumulate in sediments and organic matter, water is generally the only medium tested. No data are available on the concentration of hazardous waste that may be present in other media such as plants, soils, or shellfish in the region. The impact on biodiversity of species is also not known.

Rather than any acute impact potential that may arise from the disposal of hazardous wastes, the accumulation of hazardous chemicals such as heavy metals is our main concern. This is because sufficient dilution is available to reduce any adverse environmental effects associated with hazardous waste disposal via waterways and landfills.

Research undertaken by horizons.mw in 1995 shows that if they exist at all, adverse environmental effects associated with landfill operations in the region are minor. Given that hazardous wastes comprise less than one percent of all wastes taken to landfills, this is hardly surprising. Ongoing monitoring of contamination downstream of major landfills in the region also indicates every need for concern.

CONTAMINATED SITES

Contaminated sites are legacies of past land-uses coming back to haunt us with their risk of off-site pollution and on-site health risks. They are associated with persistent chemicals, such as heavy metals, and long-lived organochlorines such as DDT and Lindane pesticides. These chemicals can last in some cases indefinitely in the soils, but may pose serious health problems if they enter the environment or are ingested by people. Typically, they reflect times when controls on their use were far less stringent than now.

A 1992 desk-top study (Worley Consultants), assessing overall contamination in New Zealand, suggested the Manawatu-Wanganui Region could have some 600 potentially contaminated sites. However, this study was on the basis of counting up the number of companies in industry sectors associated with using hazardous substances and did not differentiate by scale of impact. Investigations to date and liaison with the different industries show that we do have contaminated sites, but they are not large scale and at this stage not presenting environmental hazard. Many have already been dealt with. Leaking petrol station underground storage tanks have progressively been identified and replaced. The timber treatment plants, associated with copper, chrome and arsenic, have also been upgraded through the resource consent process.

Investigations continue with what are arguably the largest sites, including the old borough and city gas works. These sites are known, and in most cases are not considered to be posing significant risk. For example the Dannevirke site is now covered with carpark asphalt, which effectively stops water percolation and any hydrocarbon movement as well as the rising of contaminated dust off the site. Wanganui has the only site where there is some concern, for which a more detailed investigation programme is under way.

CONCLUSION

Waste discharges are controlled by the resource consent process. Conditions attached to resource consents, and compliance monitoring, assess the environmental effects of discharges. When non-compliance occurs, both cause and effect are investigated. Abatement notices are issued where appropriate.

Current data show minor quantities of hazardous waste are generated and disposed in the region. Currently there is insufficient information as to the cumulative environmental effects of the hazardous waste, however no evidence of any chronic problems are apparent.

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PART III

COASTAL

Defining the limits to the coastal area is never easy. The ocean easily defines itself, although even that varies by tide, hence the legal definition of "Mean High Water Springs" in the Resource Management Act. But natural processes in the coastal area are no respecters of legal niceties. The west-coast dune systems, for example, encroach miles inland. Accordingly, in this section we have made an arbitrary distinction, dividing the coastal area into two parts, the narrow immediate coastal system, and the wider dune-land, or sand country.

BLOWING IN THE WIND

As much as anything, climate, in the form of prevailing westerly winds, shapes the region's western coastline. Indeed, these winds, often known to rise to gale force, have created one of the world's most extensive parabolic dunelands. Such is their power and their supplies of sediment that within decades of its marooning in 1884, the shipwreck *Fusilier* was on the landward side of the advancing dunes. And since the 1960s its steel frame has become so engulfed by sand, it is no longer visible.

Including both east and west coasts the council has approximately 160 km of coastline in its region. Its western coast extends from the Waiinu Beach in the north to Waikawa Beach, in the south, a distance of approximately 120 km. The eastern coastline extends from Cape Turnagain in the north to the Owing River mouth in the south, a distance of 40 km (see map).

From the Waiinu to the Mowhanau Streams, the coast is characterised by sandy beaches dotted with andesitic boulders and backed by cliffs sometimes 50 metres high. This is a high-energy shore, exposed to the west and south-west, with a cliff face retreating at a rate of between 40-100 cm per year.

From Mowhanau stream south the coast has 100 km of sandy beaches with gentle slopes backed by a dynamic dune system. This system is fed constantly by sand or sediment from the rivers draining the Wanganui Basin, the Central Plateau and the Ruahine Ranges. The sediment moves predominantly southward along the coast until the prevailing winds blow the sand inland, forming an extensive network of fragile dunes. In contradiction to the recession of cliffs to the north the sandy beaches grow currently at a rate of between 0.8 and 1.0 metres per year.

Along the sandy stretch of the coast the vegetation consists largely of marram grass. Natives spinifex, pingao and the introduced acacia longafolium and stands of pinus radiata are also evident.

The eastern coastline is characterised by wave-swept rocky platforms backed by boulder/cobble or sandy beaches dotted with boulders. An area of sedimentary cliffs occurs at Cape Turnagain, with a sandy beach in its lee. The river mouths have usually formed alluvial flats that join the sea as sandy bays with a north-facing spit. The rocks on the coast are medium resistant sandstone, silt-stone and mudstone. The coast is classed as a high-energy lee shore, with the prevailing deep-water wave being of southerly origin.

East coast at Akitio.

The Manawatu-Wanganui region's largest coastal settlement is Wanganui with a population of approximately 40,000. Other settlements, including Foxton Beach, Mowhanau, Koitiata, Scotts Ferry, Tangimoana, Himatangi, Waitarere, Hokio and Waikawa, have much smaller populations, though these swell during the summer months, most significantly at Foxton Beach. There are two small settlements on the east coast, Akitio and Herbertville, which also have summer increases in population.

COASTAL ISSUES

- Modification of coastal processes due to human activities.
- Degradation of the coastal environment, affecting water quality and biodiversity, including habitats and species diversity.
- Sand country erosion.

Other issues, reported elsewhere, are natural hazards, including Tsunami and pests, especially rabbits.

COASTAL ZONE RESOURCE CONSENTS (pressure)

Despite possessing a reasonable length of coastline, compared with other regions, we see little real pressure on our coast. Coastline development, for example, is very small. Consequently, there are only 26 coastal permits and only one or two are typically granted each year. The one permit granted in 1997-98 was for placing a water level monitoring station in the Manawatu Estuary.

Most consents are for the Wanganui Harbour; others include spraying spartina in the Manawatu Estuary, and reconstructing a protective wall at Akitio.

Dune erosion control, planting marram,West Coast.

GROWING ON THE DUNES: SURVEYING THE VEGETATION (state)

The sand country can be regarded as being in several broad-scale ecosystems, each related to soil age. When Maori arrived here, the inland sand country would have been mature native forest but by the time Europeans settled was mostly scrub. At the other end of the scale is the coastal strip, which holds a natural mixture of bare sand, sand herbs and shrubs, scrub and native forest. It is the sand herbs and shrubs that are among the most unique yet least appreciated vegetation types in the region. These plants are specially adapted to life on migrating dunes and dune-hollows. Several of these species are regionally unique and endangered and a couple are nationally unique and endangered. Unfortunately there is a conflict between preventing erosion and protecting the 'moving dune' habitat of these plants.

Ten large sites were surveyed, vegetation type and landform being determined at up to 100 points on each site. Only one of the 835 points surveyed had native forest while almost 2 percent of the sample was native scrub. An additional 7.5 percent of the sample had wetland plants (usually a mixture of natives and weeds) or mixed pasture and native trees or scrub. These results confirm the PNA survey of the Foxton Ecological District carried out by DOC that found only

COASTAL ISSUES INDICATORS

- **PRESSURE**: number of resource consents granted in the coastal marine area
- **STATE**: rate of beach progradation or degradation natural dune vegetation coastal sand dune profile coastal water quality
- **RESPONSE**: sand country erosion control measures

1.3 percent of the sand country effectively protected for ecological purposes. Less than 5 percent of the Foxton ecological district was estimated to have predominantly indigenous vegetation, most of this natural dune land. Almost no native forest on sand country remains.

Future monitoring will need to establish with more accuracy what percentage of the coastal strip has natural vegetation, and the state it is in.

COASTAL SAND DUNE PROFILE (state)

Progradation or retreat into the sea (degradation) of the shoreline is largely a natural process that is the result of many weather and sea variables along this highly dynamic coast. Separate coastal studies carried out by the Rangitikei-Wanganui and Manawatu Catchment Boards in the late 1970s and 80s used data from several places on the region's west coast. The idea was to study coastal dynamics and hazards in the two regions.

Fifteen established sections north of Himatangi and ten between Himatangi and Otaki Beach formed part of those studies. In 1999 they were re-surveyed using original reference points and/or benchmarks where these were located. Data are still being processed to compare surveys. However, an informal measure of the dynamics of this coastline is that of railway irons, placed along it as markers in the early 1980s, which have now, like the *Fusilier* before them, vanished entirely from view.

COASTAL WATER QUALITY (state)

horizons.mw has started a coastal and estuary monitoring programme in 1999. To date one run has been completed. At this stage, no indicators for the coastal segment have been developed.

HOLDING THE LINE: EROSION CONTROL (response)

The west coast with its shifting sand hills and accreting coastline faces significant problems with sand inundation and wind erosion. These problems are pronounced at the settlements of Himatangi and Foxton. Many years of stabilising work have been undertaken to mitigate the effects of wind-blown sand.

With the advent of farming in the region much of the indigenous sand binding plants (especially Spinifex) were grazed out by cattle and rabbits, accelerating a natural problem of loose wind-blown sand. In conjunction with the former Rangitikei-Wanganui and Manawatu Catchment Boards the local district councils carried out initial remedial work. horizons.mw has continued this tradition of assisting coastal landowners to contain wind-blown sand. To a large extent these problems have been overcome by fencing from stock and planting the sand-binding marram grass. With sand movement minimised, these areas were planted with pinus radiata.

A significant portion off the coastal area is now in production pine forest, much of it owned by Ernslaw One Ltd. who have 25 km of coastline in pinus radiata.

At Foxton and Himatangi Beach settlements, the dynamic nature of the fore dune has caused problems with sand being blown onto residential properties, roads and car parks. This is largely overcome by dune reshaping and replanting

Seacliffs, north of Wanganui.

with sand binding plants. Approximately 12 hectares of fore dune reshaping has also been carried out there in recent times. Use of heavy earth moving equipment allows the fore dune to be more aerodynamic, lessening the chance of "blow outs" or gullies forming in the dunes. It is the gullies that funnel the wind, giving rise to unstable parabolic dunes whose rates of migration are some of the highest in the world.

Two major users of the sand country, Defence Force RNZAF Ohakea and Ernslaw One Ltd, also have programmes of dune reshaping. Ernslaw One Ltd reshapes approximately five hectares of fore dunes each year to protect its forestry interests. Defence Force RNZAF Ohakea began a programme in 1998 on their coastal land that will reshape 10 hectares of unstable fore dune over the next five years. Initial work saw 2.5 hectares completed in 1998.

This reshaping is followed with marram planting to bind the sand. Marram, while not the most preferred species for sand binding, is the most economic. Easy to establish, it is reasonably abundant compared with the native alternatives of spinifex and pingao.

horizons.mw is keen to promote the use of native sand-binding plant species. To encourage this, in conjunction with UCol's Levin Horticulture campus, we are looking at economic ways of harvesting spinifex seed and the propagation of sufficient numbers of spinifex plants to make its use an economic alternative to marram grass.

The fertilising of the fore dune vegetation with NPK fertiliser is beneficial with a large growth response achieved. Most coastal properties apply some fertiliser to encourage the dune vegetation. Ernslaw One uses 25 tonnes of urea in two applications to 250 hectares of the coastal strip. The local district councils of Manawatu, Horowhenua and Rangitikei have applied 12.5 tonnes of Nitrogen, Phosphorous and Potassium fertiliser in the 1998-1999 growing season.

SANDS OF TIME: SOIL EROSION IN THE SAND COUNTRY

At 79,000 hectares, the Manawatu sand country is the largest dune field in New Zealand and, despite many recent changes to it, is one of the most significant in the world. In the last 25,000 years there have been five main phases of dune erosion. The oldest phase, found furthest inland, has the best developed soils. The youngest phase is the actively eroding coastal fore dune. The soils on the dunes and some of the dune flats are thin, and easily erodible.

The main land uses on the plains are farming and forestry. As in the hill country, the original forest and scrub vegetation was almost completely cleared, resulting in widespread dune erosion on the fore dunes and Waitarere phase dunes.

Much of the exotic forestry was established as a response to erosion and because forestry is relatively attractive economically on sand country. The combination of rabbits and stock on these dunes often results in small patches of bare sand. Strong winds, common in spring and autumn, can cause localised 'blowouts'. Once eroded, the topsoil is gone, and the site will remain sensitive to wind erosion for years to come.

Coast between Foxton and Himitangi.

SOIL EROSION INDICATORS

- **PRESSURE**: protective vegetation cover
- **STATE**: barrenness and revegetation
- **RESPONSE**: afforestation

Techniques to control and prevent erosion include maintaining a dense pasture sward, rabbit control, spinifex and marram grass planting and afforestation.

PROTECTIVE VEGETATION COVER (state)

Around 70 percent of dunes and 85 percent of flats have vegetation considered to be 'protective' against erosion. This is a far higher percentage than for the hill country, partly because forestry is more profitable on sand country. Protective vegetation includes dense pasture, marram and dense trees or scrub, but not depleted pasture with scattered trees or scrub.

BARRENNESS AND REVEGETATION (state)

Initial survey work suggests seven percent of the dune flats and 23 percent of the dune ridges are bare or revegetating, containing no soil. The area of bare and revegetating scars is an index of the amount of eroded versus undisturbed soil on the sand country.

AFFORESTATION (response)

Together, horizons.mw and landowners spend about $100,000 a year on afforestation and marram planting projects in the sand country using the Environmental Grants scheme. This protects between 100 and 200 hectares of pastoral land per year.

The area of marram and exotic forestry can be taken as an indicator of the size of the response to the erosion issue. Forty-seven percent of the unstable sand dunes and flats have been either afforested or planted in marram grass. This includes 11 percent of the unstable dunes and flats (around 5000 hectares) afforested or planted in marram in the last five or so years. Only one third of the unstable dunes in the sample remain in pasture.

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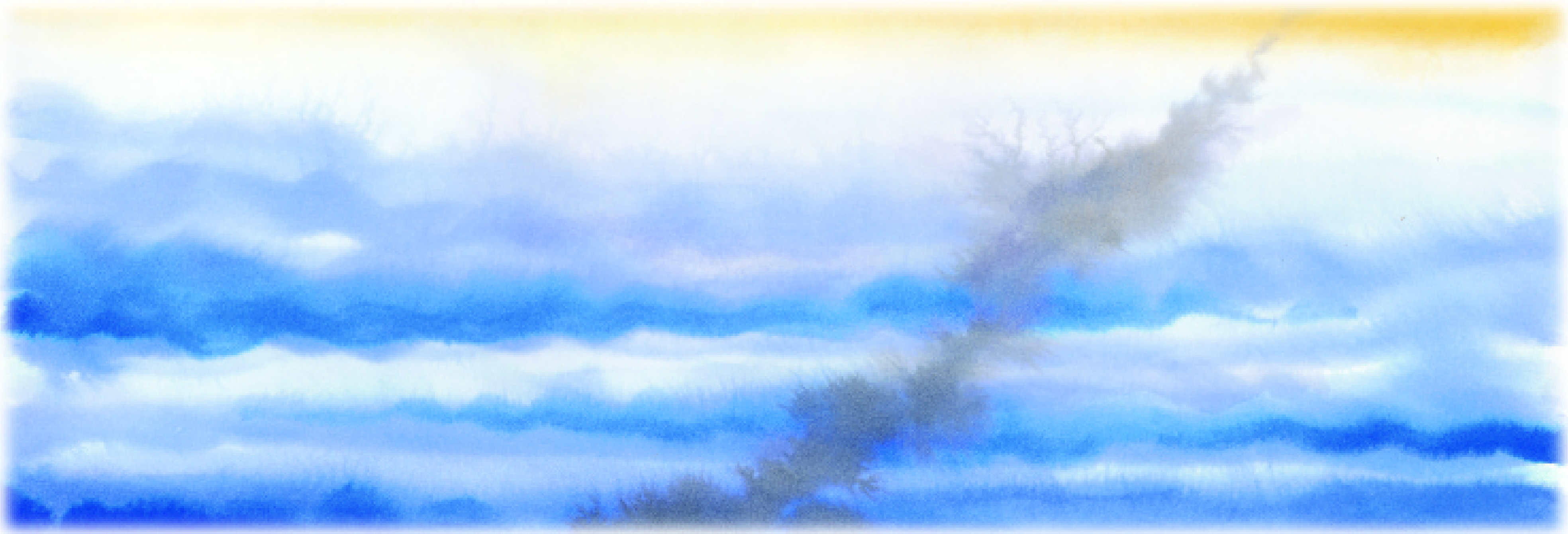
PART IV



AIR

RUMINANT AND VEHICLE EMISSIONS: AIR QUALITY

Clean air, a rarity in most heavily urbanised places around the world, is usually regarded as a given in New Zealand. Our region is no exception. With its relatively dispersed population, relatively low levels of industrial development and traffic density, air quality in the region is considered good. The main sources of pollution are methane, from agricultural sources and CO_2, from car emissions, particularly from State Highway One that runs north-south for the length of the region.

Here the classical air pollutants such as oxides of sulphur and nitrogen and ozone, count for little. What concerns exist are largely about aesthetic qualities such as visibility and odour.

AIR DISCHARGE INDICATORS

- **PRESSURE**: Emission inventory; Resource consents issued; Complaints received
- **STATE**: Levels of deposited particulate matter measured; Visibility – an integrating measure of overall air pollution

AESTHETIC QUALITIES

In such circumstances, a good indicator of overall air quality is visibility, or the distance we can see. Whether you are a tramper who likes to look out from the ranges to Ruapehu and Kapiti, or just a local enjoying a view of the expansive plains and uplands of the region on a still autumn day, people place a high value on good visibility.

Degraded visibility caused by air pollution is not common in this region. However localised meteorological conditions, notably windless days, that limit the dispersion of pollutants, sometimes occur. Visibility can then be affected. It may also be degraded on a local scale by an event such as agricultural burnoff.

Fresh smelling air is reasonably assumed to indicate that it is free from pollution; air that is not fresh smelling is taken as an indication that contaminants are present. Some communities in the region have lived with a particular source of odour over a period of many years. While some communities accept particular odours as an inevitable product of a particular operation, other communities are increasingly objecting to frequent odours they perceive as being offensive.

Objections have arisen in residential areas near industries such as tanneries, fellmongeries, abattoirs, and wastewater treatment plants. Such incompatible neighbouring activities have arisen largely from historical planning practices that did not recognise adverse effects to "neighbourhood values".

Mt Tongariro and Mt Ngaruhoe.

AIR DISCHARGE SOURCES IN THE REGION

Like those to water, contaminants discharged to air are from a range of sources. They can be grouped according to whether the source is natural or human-made, a point source or an area source, stationary or mobile, and rural, domestic or industrial. Examples of natural sources are:

- wind blown dust and dirt
- volcanoes (dust/ash and sulphur dioxide)
- geothermal, for example, Rotorua (hydrogen sulphide) biological degradation, methane, carbon dioxide, hydrogen sulphide, ammonia).

Human made sources include:

- transport, for example, motor vehicles (lead, carbon monoxide, nitrogen oxide)
- industry, for example, spray painting, joineries, meat works, sewage treatment plants, combustion, quarrying, asphalt/hot mix plants
- domestic, for example, home fires and incinerators
- rural, for example, agri-cultural burn off, chemical sprays, silage odours.

Degraded amenity value of air

is a significant air quality issue in the region. The main concern is the effect of nuisance discharges caused by human-made sources, such as dust, odour and agricultural chemical spraying.

WHEN THE BALLOON GOES UP: AIR POLLUTION INCIDENTS (pressure)

The Council recorded 143 air pollution incidents for the year 1997-98. The total number of air pollution incidents reported has not changed significantly since 1995-96, however a sharp increase has been recorded and since 1991-92 when approximately seven were received. The considerable increase from 1991-1995 reflects increasing public awareness that responsibilities for air quality, previously under the Department of Health, were now transferred to regional councils under the Resource Management Act.

PUBLIC RESPONSE: COMPLAINTS RECEIVED (pressure)

The first line of detection of changes in air quality is often information provided by the public. Their perceptions have provided horizons.mw with a subjective assessment of air quality. Pollution complaints to the regional and district councils and community surveys are the main sources.

horizons.mw recorded 143 air pollution incidents for the 1997-98 year. This total does not include notifications made to the Wanganui District Council odour phone, which are reported separately. The total number of air pollution incidents reported annually has not changed significantly since 1995-96. Reported incidents include odour, dust, spray-drift, smoke and solvent/paint fumes.

The dominant complaint or notification concerns odour, making up approximately three quarters of air pollution incidents. Most implicate the same few firms as culprits. Approximately half of the notifications in 1997-98 concerning odour came from Levin where Lakeview Farm Fresh Ltd was alleged to be the cause of the problem. Other potential sources of offensive odour in the area are from the Levin Sewage Treatment Plant and a pet food manufacturer. It is predicted that there will be a significant reduction in the number of air incidents when Lakeview Farm Fresh Ltd achieves compliance with its air discharge permit.

In 1994 horizons.mw carried out a region-wide newspaper survey called "How Clean is Our Air?" Public response to five topics was sought: general air quality, odour, dust, smoke and spray drift.

There were 198 respondents to the survey. Seventy-nine percent felt that air quality was either excellent or good in winter. Slightly fewer, 71 percent, felt that air quality was also either excellent or good in summer. We might conclude from the survey that the region does not appear to have widespread air quality problems, but that at a local level some problems are significant. This causes some people to regard air quality in their area as poor. Common contributors to this were: odour; smoke from burning rubbish; dust from unsealed roads or yards; and the use of chemical sprays.

A survey was also carried out by horizons.mw in late 1994 to identify the cause of an odour problem in Levin. Results of the survey were that 74 percent of the respondents had been "bothered" at some time by the smell from Levin's Sewage Treatment Plant, and 66 percent identified the Sewage Treatment Plant as the worst smell they experienced in their area.

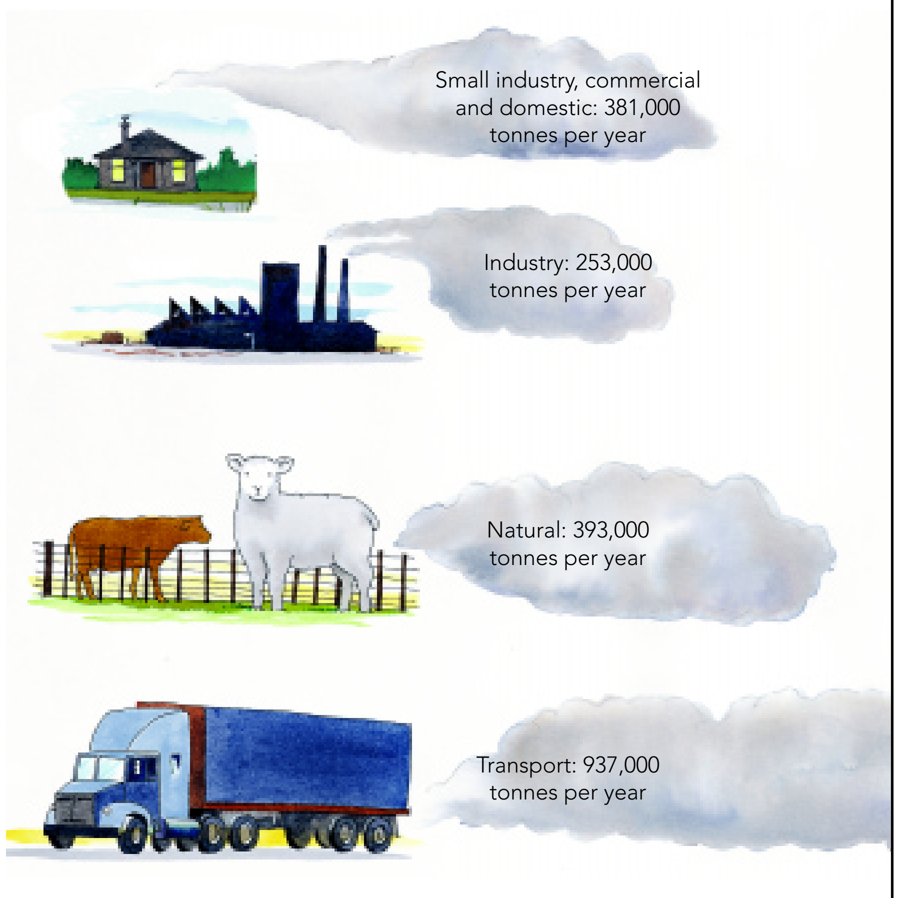
Winstone Pulp international, Karioi.

RESOURCE CONSENTS (pressure)

As at March 1999, there were 150 resource consents for discharges to air (either current or in the application process). Fourteen consents for discharges to air were granted in 1997-1998, a decrease of around 33 percent from the previous year. It is expected that this trend will likely continue as a reflection of Regional Air Plan provisions, operative from January 1999.

Resource consents for discharges to air are issued for the following activities: chemical spraying; combustion appliance emissions; dust; emissions; heat; landfill gases; odour; particulate; sandblasting emissions; smoke; and steam. Thirty-five consents have been issued for landfills in the region relating to landfill gases and odour. The majority of consents are for discharge of odour, dust, particulate and sandblasting emissions.

FIGURE 19: Source sector emissions



AIR EMISSION INVENTORY (pressure)

Most places in the Manawatu-Wanganui region appear to have air that is free from the levels of pollution adverse to people's health. The Air Emission Inventory, undertaken as a "desk-top" study in 1998, quantifies air emissions. It is the first step towards providing an objective overview of the air quality in the region.

The inventory is a compilation of the sources and respective quantities of pollutants that are being discharged to air. The study focused on pollutants within air emissions from industrial, transport, area, and natural sources.

FINDINGS

We calculated nearly 2 million tonnes of pollutants are discharged to air in the region every year. Most air emissions in the region are from the transport source sector, contributing almost 50 percent of the total air emissions (Figure 19). This amount is significant, however it is not surprising given that State Highway 1 runs through a significant portion of the region.

Area (non-specific source, small industry, commercial and domestic sources) and natural source sectors each contribute to approximately 19 percent each of total emissions. However, the study did not consider emissions from gravel extraction or quarrying works which means the area source sector estimation is probably underestimated, specifically for the total suspended particulate matter.

Air emissions from the industrial source sector appear to contribute the least pollutants relative to natural, area, and transport source sectors. With the region's relative lack of industry it is expected that this source sector will remain minor compared with other source sectors.

Carbon dioxide (Co_2), derived from all sectors. is the largest contributing pollutant to total emissions, 1.6 million per annum, mostly from combustion processes.. Volatile organic carbon (VOC) emissions (methane and non-methane hydrocarbons) are also significant. This is a concern particularly when considered in terms of greenhouse gas carbon dioxide equivalents. The amount of methane generated from animals, mainly sheep, in the region was estimated as 0.17 million tonnes per year (45 percent of total natural source sector emissions). Since the carbon dioxide equivalent for methane is equivalent to 12 parts of carbon dioxide, the methane therefore represents 2.1 million tonnes per year. This is greater than the regional total of 1.6 million tonnes for carbon dioxide!

This gives a total CO_2 equivalent loading of about 3.8 million tonnes per year. Since different methodologies are used, accurate comparisons between regions is difficult. However CO_2 emissions are about 3 percent of Auckland's and half of Wellington's. Annual tonnage per capita (5-6 tonnes per year) are comparable to other, less populated regions, underlining how population size can be as important to clean air as any management response.

Other pollutants were minor in relation to CO_2 and VOC emissions. Volcanic emissions, from Ruapehu eruptions, account for most of the SO_x (Oxides of Sulphur) emissions. Total suspended particulate emissions are negligible, however high particulate generating activities, such as quarrying and gravel extraction, were not assessed in the inventory.

PARTICULATE MONITORING (state)

This programme has only begun, and insufficient data have been collected to report on.

VISIBILITY MONITORING (state)

In 1997/98 the Ministry of the Environment commissioned horizons.mw (in conjunction with Taranaki Regional Council, Environment Waikato, Hawke's Bay Regional Council and NIWA) to carry out a study of new techniques that could be used for visibility monitoring in New Zealand.

From trials around New Zealand, it appears the easiest and most useful method for monitoring visibility is a visibility survey. The advantage is that, although subjective, the use of a survey provides first hand information.

The use of digital image processing techniques was also tried as a low cost method for measuring visibility. A NetEye digital camera was installed on the second floor of the Manawatu Science Centre and Museum in Palmerston North in December 1997. Several problems relating to height, location and sunlight were found with the site after installing the camera. However, although still experimental, the technique shows promise as an excellent quantitative tool for measuring visibility.

Both methods will be investigated further.


Trampers in the moutain air.

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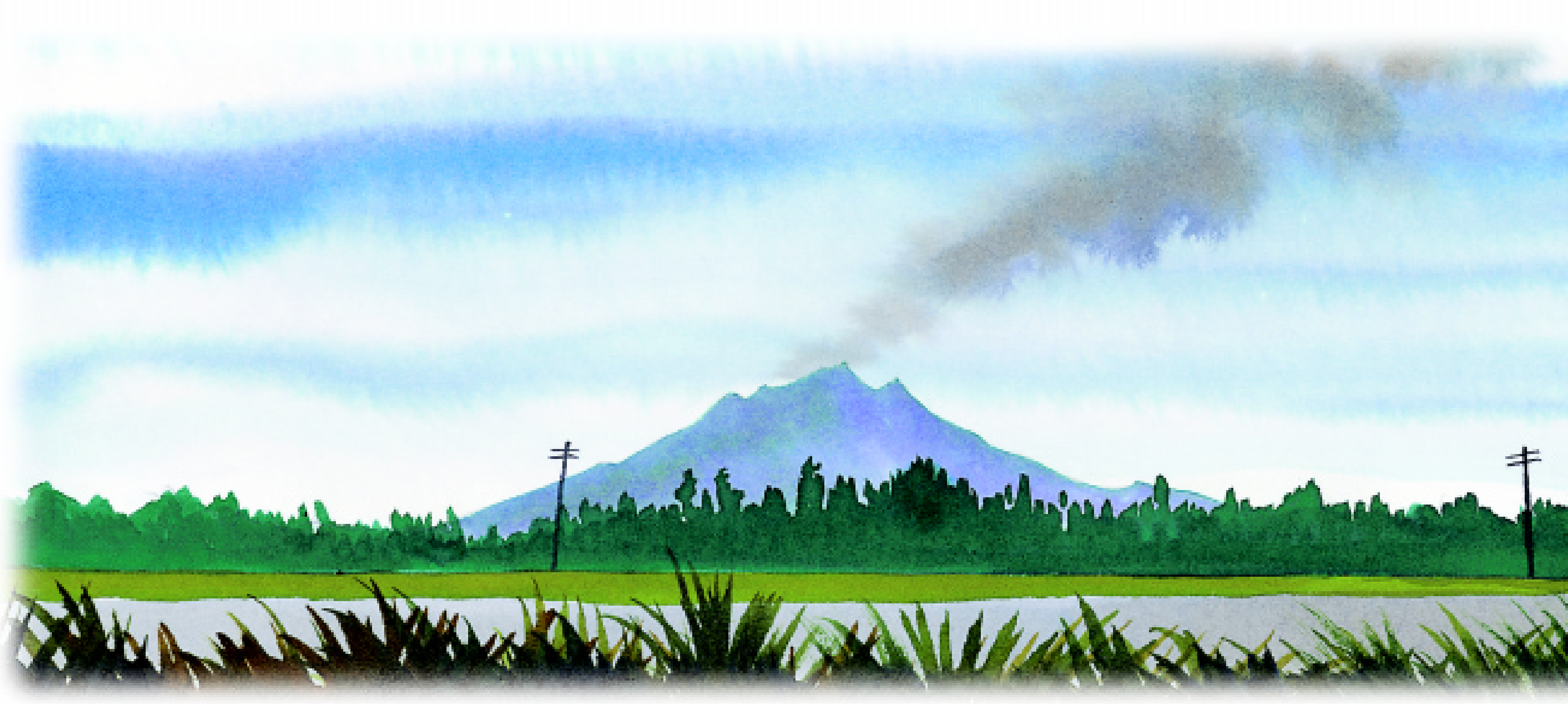
ON THE HORIZON: SUMMARY

A first report such as this, seeking to identify and pull together the different threads of our region's natural and physical resources and their management, will inevitably be something of a swiss cheese – remarkable for its holes. Some subjects will invariably be overstated and others, no less important, understated.

This patchiness reflects our understanding of and information on our region's resources, rather than any preoccupation on the part of the authors. Some gaps are only temporary, reflecting monitoring programmes too recently established to provide meaningful data. And queries rather than conclusions are the only valid result for others until we collect more data to identify pattern and trends. So, this patchiness sets a context for setting an agenda to fill those gaps. Setting the agenda also requires further work assessing their significance and priority in this region.

This first report indicates a mixed performance. The region has made significant environmental improvements in some areas, but there are question marks hovering over others. Generally, we could claim that our environment in the short term at least appears in reasonably good condition overall, and business as usual can prevail for a while yet. Our skies are clear, and water quality through much of the Region is in far better condition than in previous decades. Agriculture remains productive

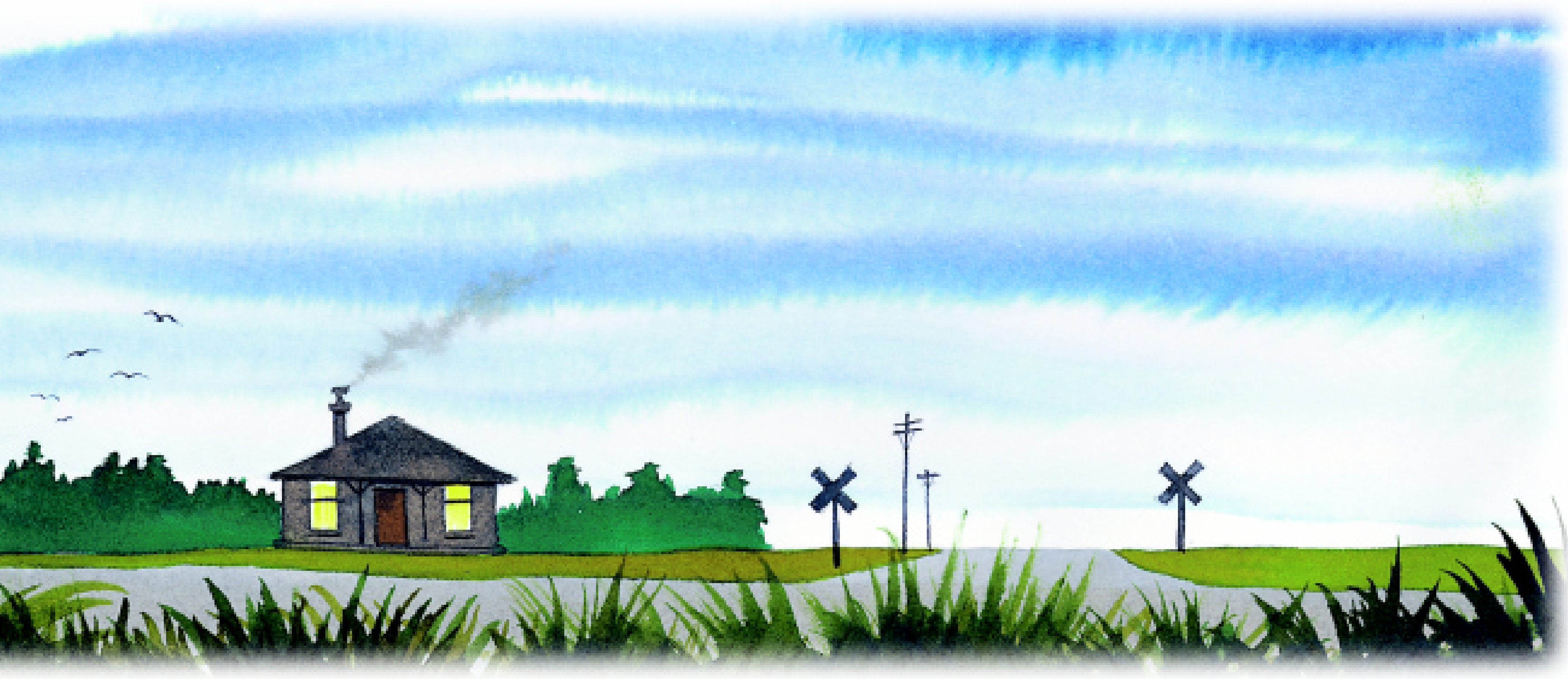


and our communities which depend on our natural resources for their well-being still prevail in the main.

However, the Report contains several warnings and even the question marks suggest that all may not be well in the medium to long term if we continue following current resource use practices. High ground water nitrate levels in the Horowhenua, marked soil loss in Ohakune-Raetihi cropland, and ground water table drops around Feilding, are all immediate cause for concern. Biodiversity degradation, more obviously from pests, and less obviously from slow degradation and eventual loss of isolated remnants of once common bush stands are signalled by key-stone species. River water is better than previously, largely as the result of less specific discharges. But there could well be less available in the future to meet all our needs, and worryingly, in some streams and rivers water quality is degraded upstream of traditional polluting sewage outfalls.

We appear to have no significant industrial legacy typical of industrialised conurbations – typically manifested as air pollution and large scale site contamination. But contaminated soils on the old gas works sites demonstrates we have no immunity. Instead, it reflects the region's small-scale industry, rather than good management.

Perhaps of more concern is that we still do not know the long term impacts and their implications of many of our farming practices in the region. Indeed many issues raised in this report can be traced back to the



agricultural sector. This is not to pick on agriculture, rather recognising that these effects are the inevitable consequence of agriculture being the dominant land-use in the region and by far our largest industry.

Tradeoffs are required and there would appear to be overall acceptance that we are not in the business of turning the clock back. For example, most of us accept our swamps and indigenous forests have irreversibly been converted to farmland. But restoration in some cases is going on.

The challenge is now identifying whether less obvious change from current farming practices is continuing overall environmental degradation. If so, question marks must be placed not only over sustainable management of our natural and physical resources in the region, but also over our regional economy's long term viability.

But even maintenance at present levels cannot be taken for granted, and is likely to require resources. For example, animal and plant pests continue to threaten our natural heritage and primary production. Their management remains reactive, combating established populations. This requires high resource input even to maintain existing levels. We can foresee these resource levels are not sustainable in the long-run, especially if they have to be spread to address infestations of new pest species.

In conclusion, we can see that questions remain about whether we are achieving sustainable management in the Manawatu-Wanganui Region.