Te oranga o te taiao
Waikato State of the Environment 2022

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Rārangi kaupapa
Contents

Toitū te taiao

Horahia te aroha o Ihowa	Send out the love of the Creator
Māroharoha ki ngā hau e whā	Spread it to the four winds
He aroha kāmehameha	A most precious gift
Tiakina te taiao kaua e tūkinotia	Look after our environment, do not exploit it
Hei ōranga mō ngā uri whakaheke	So it can be a life source for generations to come
Takatū ake rā e te iwi ki te whawhai whenua	Get ready to fight for our land
Tēnei mātou te tira taiao	We care for the world in which we live
E poipoia nei te kaupapa	This is our cause
Kia ū kia manako nei te tū	Let us hold to what we stand for
Toitū te whenua, toitū te tangata, toitū te taiao	Sustain our land, strengthen our communities, care for our environment
Te ao mārama nei e	

He kupu whakataki
Executive summary

This report describes the state of the Waikato region's environment through 2022, and makes recommendations to improve environmental outcomes.

There is a wealth of knowledge on the Waikato environment, to which this report contributes learnings from the state of environment monitoring by Waikato Regional Council. This information will be used to inform policy development and support actions. Particularly in giving effect to the National Policy Statement for Freshwater Management. Mana whenua within the region are the source and orators of Mātauranga Māori, which is also used to inform policy and actions.

The Waikato region is rich in natural resources, including New Zealand's longest river and largest lake, around a quarter of its high-class soils, most of its geothermal resources, its largest karst area, as well as internationally significant wetlands.

Air quality in the region is mostly good, but sometimes in winter, some urban areas do not meet national air quality standards.

A rising population has seen urban development encroach on surrounding farmland. The area of land used for pastoral farming and land use intensification have both increased, driven by conversion of planted forest to pastoral land and dairy farms.

Soil quality is improving overall, but compaction and excessively high soil fertility are still issues on some farms.

Just over a quarter of the land is covered in indigenous vegetation. About 75 per cent of the region's peatlands have been drained, releasing significant emissions of carbon dioxide, which contribute to climate change.

River flow has reduced markedly, due to less rainfall, increased evaporation and increased water use for irrigation. Water security is of increasing concern for the Waikato region, particularly for the growing populations of Hamilton and Auckland.

The load of contaminants to rivers from municipal and rural point source discharges has decreased, contributing to decreasing phosphorus levels in rivers.

Diffuse nitrogen has continued to worsen in many rivers and streams, but Lake Taupō is achieving water quality targets ahead of schedule following the introduction of a nitrogen cap and trade scheme. Despite extensive fencing and planting of streambanks by farmers and community groups, bacteria levels in our rivers remain high, and both farmland and urban stormwater are likely sources.

In many of our rivers and streams, sediment levels remain high. The biodiversity and ecosystem health of many riverine and peat lakes, streams, harbours and estuaries are degraded or declining. High erosion and increasing nutrient inputs are key pressures on our estuaries.

Many shallow lakes are dominated by algae blooms, and are one of the region's most sensitive receiving environments for nutrients.

Lowland waterways are in a degraded state, and many rivers do not meet national bottom lines for ecosystem health. Biodiversity loss is more pronounced in lowland streams draining developed catchments. Native fish diversity is likely to be constrained by barriers to movement.

Wetlands and forest continue to be subject to development pressure. The gains from planting native trees have been countered by clearance of indigenous scrub and shrubland elsewhere.

Freshwater has been a focus of state of the environment monitoring to date, and the changes reported here are limited to the changes we monitor. For example, measuring the spatial extent of wetlands from satellite imagery will only reveal change if a stand of vegetation is lost entirely.

Back to top

To improve environmental outcomes, the following broad recommendations are made:

- There are gaps in our monitoring of wetlands, forests, biosecurity, geothermal and coastal waters. This increases the risk of significant changes going unreported. Additional monitoring is recommended in these areas.
- Focus on better management of critical source areas in farm plans to tackle increasing levels of bacteria in waterways.
- Develop controls for diffuse nitrogen to manage increasing levels of nitrogen in waterways (particularly for streams draining to the Firth of Thames and shallow lakes).
- Better protect soils from erosion, and stream banks from collapse, for example, by fencing and planting areas of west coast harbour catchments.
- Better pathways to and from the sea for migratory fish by regulating new structures and remediating existing structures.
- Continue clean heat incentives and education campaigns in Tokoroa and extend them to other airsheds which may not meet new $PM_{2.5}$ standards, if introduced.
- Recognise a growing water availability deficit for the Waikato region by improving water use efficiency, investigating storage options and improving ecosystem resilience to low flow periods.

Wāhanga tuatahi
Part 1

He tīmatanga kōrero
Introduction

The Waikato State of the Environment (SOE) report is based on detailed interpretation of decades of environmental monitoring data provided in 23 technical reports. Each technical report covers a specific environmental domain (such as stream ecology or coastal water quality). This report synthesises the information across the domains and provides a condensed, integrated description of the Waikato environment.

The SOE report is just one of many outputs of Waikato Regional Council's environmental monitoring programme. Monitoring results for individual sites can be found in the technical reports underpinning this report (see Part 11 Further reading), on the national LAWA website and on the Environmental data hub for the Waikato region. The Waikato River Authority uses the environmental monitoring data to report on progress toward *Te Ture Whaimana o te Awa o Waikato – Vision and Strategy for the Waikato River* and summarises it in report cards. The Waikato Maps page provides interactive maps of land cover and other spatial information.

For a nationwide synthesis, the Ministry for the Environment produces an SOE report every three years, with more frequent updates of national indicators generated by StatsNZ.

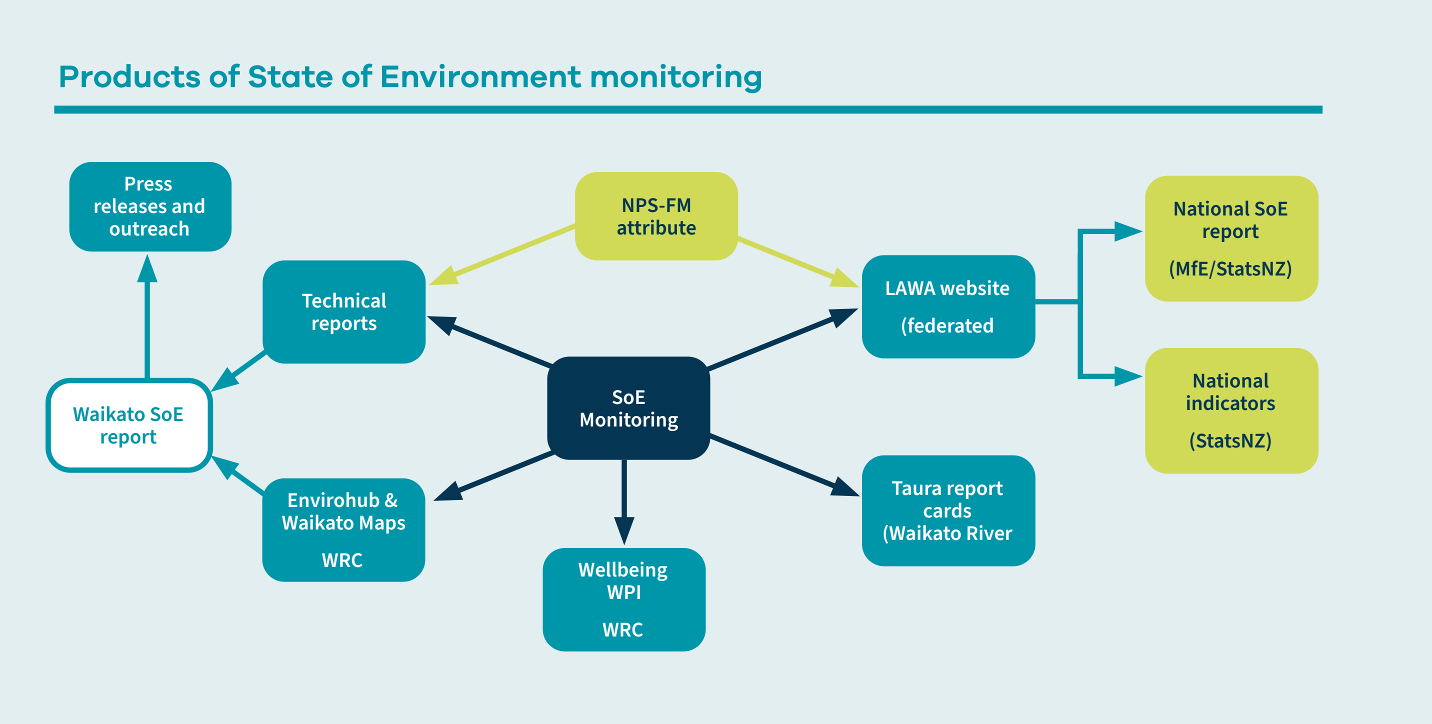


Figure 1: This SOE report brings together information from technical reports that interpret monitoring data. Monitoring data is used in a variety of ways, some of which are captured here.

Unlike the national report, this Waikato SOE report makes recommendations on changes to improve environmental outcomes. Waikato Regional Council is required to produce SOE reports every five years, with annual updates. The council's SOE programme provides robust information to inform policy development and support a range of actions by our region's people. It adds to, rather than replaces, the wealth of knowledge from other sources (e.g. National Vegetation Survey).

This report considers more than just the state of the environment – to achieve better environmental outcomes, we need to understand how resource use affects the environment. To do this, technical reports were produced using the DPSIR (Drivers, Pressure, State, Impact and Response) framework. The DPSIR framework views environmental reporting as a feedback loop for resource management. The distinction between pressure, state and impact depends on the context. For example, pollution is a *pressure* on ecosystem health (for example, the health of fish assemblages), but might be reported as a *state* attribute in a water quality report (for example, nutrient concentrations in a waterbody).

This report follows the Parliamentary Commissioner for the Environment's (PCE 2019) recommendations to focus on:

- what we have (Part 2)
- what we are at risk of losing (Parts 6 to 9)
- what we can do about it (Part 10).

In line with this approach, this report does not systematically review all that we monitor, but instead focuses on specific issues arising from the technical reports which may be of concern for the people of the Waikato.

This report is based on decades of precise, systematic monitoring of the natural environment by Waikato Regional Council. It does not cover all aspects of the environment in equal measure, instead making important contributions on the topic of freshwater quantity and quality. Council has not monitored recent changes in forest health. And the historic loss of wetland extent is better understood than the loss of fish communities. These are the challenges of environmental reporting.

People with an inter-generational knowledge of the natural environment are an important source of information. Monitoring and understanding the state of the environment has always been an integral part of te ao Māori. Historically this was through an intimate, in depth knowledge of surrounding environments. Mātauranga and tikanga are deeply grounded in each place, and this cannot be captured in a few pages of text. Iwi have stated that council reports are not to be the source of their knowledge, or make statements on matters like cultural health on their behalf. Mana whenua within the Waikato region maintain their rights and responsibilities as kaitiaki, and as the source and orators of their knowledge and aspirations.

Mātauranga Māori is a legitimate body of knowledge that can directly contribute to council policy, alongside the natural sciences and the aspirations of iwi, hapū and the Waikato community. Much of the environment had changed before scientists started monitoring.

> *This report describes the state of the environment for the Waikato region, compiled in 2022 and drawing on the full period of record.*

Back to top

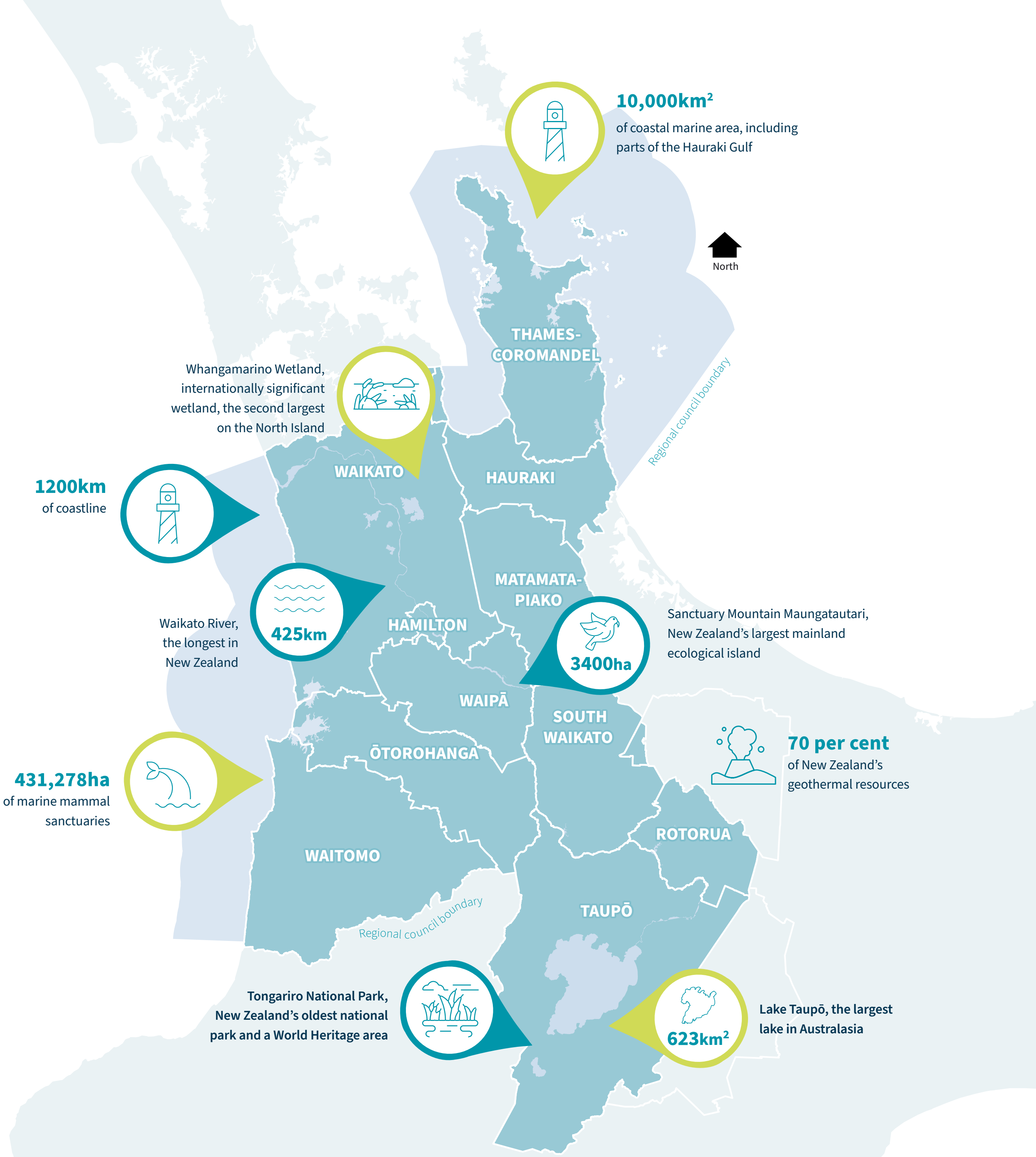
Our region at a glance

25,000km^2
land area

214,609
Rateable properties

10 Districts **1** City

458,202
People



10,000km^2
of coastal marine area, including parts of the Hauraki Gulf

Whangamarino Wetland, internationally significant wetland, the second largest on the North Island

1200km
of coastline

Waikato River, the longest in New Zealand
425km

Sanctuary Mountain Maungatautari, New Zealand's largest mainland ecological island
3400ha

70 per cent
of New Zealand's geothermal resources

431,278ha
of marine mammal sanctuaries

Tongariro National Park, New Zealand's oldest national park and a World Heritage area

Lake Taupō, the largest lake in Australasia
623km^2

Back to top

Principal iwi groups

The principal iwi groups in our region are Waikato, Maniapoto, Raukawa, Hauraki, Te Arawa and Tūwharetoa. Within these iwi groups there are numerous iwi and hapū. The iwi group areas shown in this map are overlapping and are provided as an approximate guide only. The map is not intended to depict every iwi and hapū area of interest within our region.

Back to top

Te ao Māori

Te ao Māori perspectives grow from whakapapa (genealogical) relationships with the natural world. The relationship between people and all parts of te taiao is familial and reciprocal; we are whanaunga with all aspects of the environment.

Tribal experts, elders and those who practise ahi kaa are vital to understanding the state of the environment. The mātauranga and applied experience of their local environments provide a specific understanding of place. Mātauranga Māori is a holistic way of knowing. It is unique to each iwi and is founded on the interconnectedness between knowledge, people, the environment and the metaphysical.

Te ao Māori approaches are grounded in an ethic of restoration that prioritises deep reciprocity, balance, physical and spiritual wellbeing and the mana of te taiao. These principles are gifted through generations, reaching right back to the creation of the natural world through the separation of Ranginui and Papatūānuku. Whakapapa connects us to all parts of the environment with atua as spiritual beacons for the use of the environment by people. Whakapapa is also a conceptual network that prioritises mātauranga and tikanga Māori to inform and transform people's understanding and use of the environment.

For tangata whenua, kaitiakitanga speaks to the responsibilities to ensure that the environment is protected and restored. Kaitiakitanga defines the environment as more than biophysical. Te ao Māori perspectives include concepts such as mauri (life force) and wairua (spirituality) as integral components to understanding environmental health. The physical and the 'unseen' are interconnected; therefore, understanding the state of mauri of the environment is as vital as understanding biological indicators.

Moreover, people are seen as inherently connected to the environment; and have whanaungatanga (familial) relationships with the environment. This is illuminated in many whakatauki such as *"Ko au te awa, ko te awa ko au. I am the river, and the river is me"*. This means that monitoring and reporting on the state of the environment tell a great deal about the overall health and wellbeing of whānau, hapū and iwi.

Mana whenua is the authority derived from the land. It is often used to refer to hapū who have historical and territorial rights and responsibilities over land. Localised connection to place provides a unique place from which to speak that is derived from whakapapa. Connected to mana whenua is ahi kaa. Ahi kaa, translated, refers to the 'home fires' and is applied to people who maintain the mana of the hapū and iwi on the land. Te Tiriti o Waitangi affirmed the rangatiratanga of iwi and hapū. It also guaranteed the protection of taonga (treasures), both tangible and intangible. Together, mātauranga Māori and the natural sciences give us greater insight into environmental changes. Including mātauranga Māori deepens our collective understanding of connections, interdependencies and long term perspectives. Mātauranga Māori also promotes an intergenerational view of actions taken now.

> *Mātauranga Māori is a holistic way of knowing. It is unique to each iwi and is founded on the interconnectedness between knowledge, people, the environment and the metaphysical.*

Understanding the depth and intricacies of mātauranga provides essential insights into the environment's health. Within te ao Māori, for example, there are multiple names and characteristics for different kinds of water, winds, weather and soil. Ancestral stories and atua guidance speak to ways of being with the environment that promote balance and sustainability. Environmental tohu (such as Matariki) describe environmental health and wellbeing. The richness and nuance of mātauranga can inform and transform environmental wellbeing for generations.

Working towards environmental management that is culturally responsive and holistic is vital to recognising the uniqueness of the Waikato region's physical, spiritual and cultural environments.

Back to top

Wāhanga tuarua
Part 2

Ngā rawa taiao
Our natural resources

The Waikato region stretches from the Coromandel Peninsula in the north to Mt Ruapehu in the south. Visitors from around the world often marvel at the diversity of land and water contained in such a small area, from volcanoes and tomo to surf beaches and harbours.

The highest point of the North Island, Mt Ruapehu, is both an active volcano and a popular skiing destination.

Surfable waves are found year round at Waikato beaches. The west coast's rugged black sand beaches contrast to the east coast's sheltered white sand beaches. Raglan is exposed to the prevailing westerly wind and powerful swells propagating from the Southern Ocean and Tasman Sea. Its black sand, eroded from volcanoes to the south, can still feel hot as lava on a summer's day. On the sheltered east coast, large swells occasionally reach the Coromandel Peninsula from ex-tropical cyclones.

Reliable rainfall is another benefit of the oceanic setting and prevailing westerlies. A spread of rain throughout the year keeps rivers flowing and plants growing. Higher rainfall and less evaporation in the mountains and ranges together sustain higher flows in mountain streams.

New Zealand's longest river, the Waikato River, starts its journey on the snowy peaks of the active volcanos of Ruapehu, Tongariro and Ngāuruhoe before accumulating in New Zealand's largest lake, Taupō nui a Tia. The lake fills the caldera of a super volcano that generated the largest eruption planet Earth has seen in 70,000 years. The aftermath of violent eruptions are calm rivers with subdued flooding and a high baseflow.

Over time, many eruptions built up light pumice soils across the central North Island. This enables the volcanic plateau to soak up heavy rainfall and recharge vast aquifers that sustain many springs. The large size of Lake Taupō further lessens flood peaks.

More than a third of New Zealand's population live in towns sustained by these stable rivers, including Huntly and Hamilton on the Waikato River, and Putāruru and Te Aroha on the Waihou River. The naturally stable flow of the Waikato River has been further tamed by hydroelectric dams. The nation's largest city, Auckland, is increasingly dependent on the Waikato River's high baseflow to see its growing population through drought.

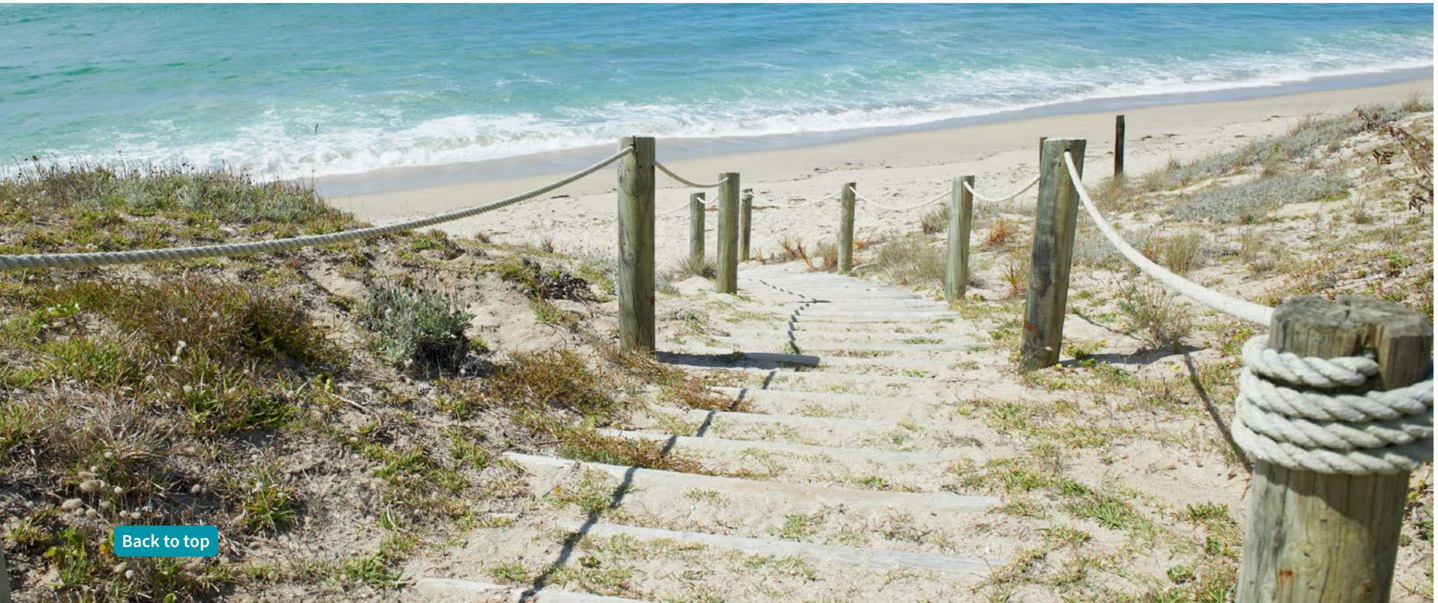
> *Around a quarter of New Zealand's land area of 'high class soils' are found in the Waikato.*

Stable flows, cool waters and pumice sand also shape river ecosystems. Some native species thrive in the volcanic plateau's spring fed rivers and crater lakes, as do rainbow trout, creating a world-renowned fly-fishing destination.

Approximately 70 per cent of New Zealand's geothermal resources and 74 per cent of its geothermal vegetation occur within the Waikato region. Heat rising from the shallow magma below reveals itself as geysers, boiling mud and sinter terraces. The Taupō Volcanic Zone is captured in the stories of Ngātoroirangi, who came to Aotearoa on the Te Arawa waka. Climbing Mt Tongariro, Ngātoroirangi, the tohunga (priest) of Te Arawa, was struck by the extreme cold and summoned his sisters in Hawaiki to help him create the geothermal features in a direct line from Tongariro to White Island.

The geothermal resource of the Taupō Volcanic Zone is harnessed to generate power. The region's nine geothermal power stations produce 15 per cent of the nation's electricity. In the centuries before power stations, people put the geothermal energy to direct use in numerous ways, from growing food to cooking, to ceremonial use and bathing.

Back to top



Back to top

Our rivers are another major source of renewable electricity, with eight hydroelectric dams on the mainstem of the Waikato River, and the Tongariro Power Scheme in its headwaters.

Productive soils are a key natural resource for feeding people, and around a quarter of New Zealand's land area of 'high class soils' are found in the Waikato region, generally on flat to gently sloping land, ideal for agriculture. Good soils, together with reliable rainfall, enable a wide range of land uses, including pasture, cropping and horticulture.

These productive soils and steady rain once supported lowland forest and wetlands. Three remaining wetlands are of international importance, listed under the Ramsar Convention, including the Kopuatai Peat Dome, extending over 10,000 hectares of the Hauraki Plains. The high water table inhibits the breakdown of plant matter, which has accumulated over thousands of years to form peat. Each year, these soils store an additional 0.6 to 3.7 tonnes of soil carbon per hectare, delaying global warming.

Shore birds migrate from the other side of the planet to reach another Ramsar wetland, the Firth of Thames. Whangamarino wetland in the northern Waikato is a stronghold for bittern and black mudfish.

The Waikato region has New Zealand's largest karst area, including Waitomo's underground rivers, glow worms and deep caverns which draw visitors year-round. Limestone dissolves slowly in water to form karst landscapes including tomo, which eventually collapse revealing hidden subterranean rivers.

The natural resources of the Waikato region sustain our economy and our wellbeing. Accounting for the full value of the ecosystem services provided by our natural resources produces estimates of a similar magnitude to regional Gross Domestic Product (GDP).

Wāhanga tuatoru
Part 3

Mō tātou, mō te toiora
Our people, our wellbeing

The relationship between people (as a collective) and the environment goes beyond the impacts we have on land and water. The wellbeing of the collective is interconnected with the wellbeing of the environment. For Māori, the wellbeing of the collective is vital. Responsibility is attributed on a collective basis rather than at an individual level. Manaakitanga and kaitiakitanga manifest the collective responsibility to one another and the environment.

Waikato Regional Council is tasked with promoting communities' social, cultural, economic and environmental wellbeing. Wellbeing is captured in the purpose of the Resource Management Act 1991 to enable communities to provide for their wellbeing by promoting sustainable management of natural resources. In a 2019 amendment to the Local Government Act, wellbeing was legislated as a purpose of local government.

Back to top

The Waikato Progress Indicators (WPI) – Tupuranga Waikato – were developed to assess progress toward wellbeing in the Waikato region (Huser and Killerby, 2022). The WPI measure key economic, environmental, social and cultural attributes that together support wellbeing. The 32 progress indicators are updated annually, and are condensed into a single metric, the Wellbeing Index.

The 32 progress indicators are summarised in the 2021 WPI scorecard (refer to Figure 3), which describes the Waikato region's progress towards wellbeing over the last 10 to 15 years. Areas of improvement include life expectancy, crime and road safety. Indicators with worsening trends include overall life satisfaction, physical activity and social connectedness. From a 2022 survey, the top three reasons for worsening quality of life were poor financial situation, poor health and wellbeing, and impacts of COVID-19.

Several economic indicators increased over this period, including the value of new building consents and median household income. Income has grown by around 2 per cent per year over the last 20 years (inflation adjusted). Economic declines during the 2008 Global Financial Crisis were more than offset by subsequent gains in manufacturing and construction industries.

The number of people living in the Waikato region increased from 380,823 at the 2006 census to 458,202 at the 2018 census. From 2015 to 2020, population growth exceeded 2 per cent per year. Growth in the Māori population also exceeded 2 per cent per year, but this high growth rate has been sustained for a longer time. In the 2018 census, half of all Māori in the region were estimated to be under the age of 25, compared to a third of the total population.

Space for people to live is now a problem for the Waikato region, with an estimated shortfall of some 7500 houses. The greatest shortfall was in Hamilton city, and demand has driven urban development across surrounding farmland. The value of residential building consents increased 16 per cent per year over the last decade.

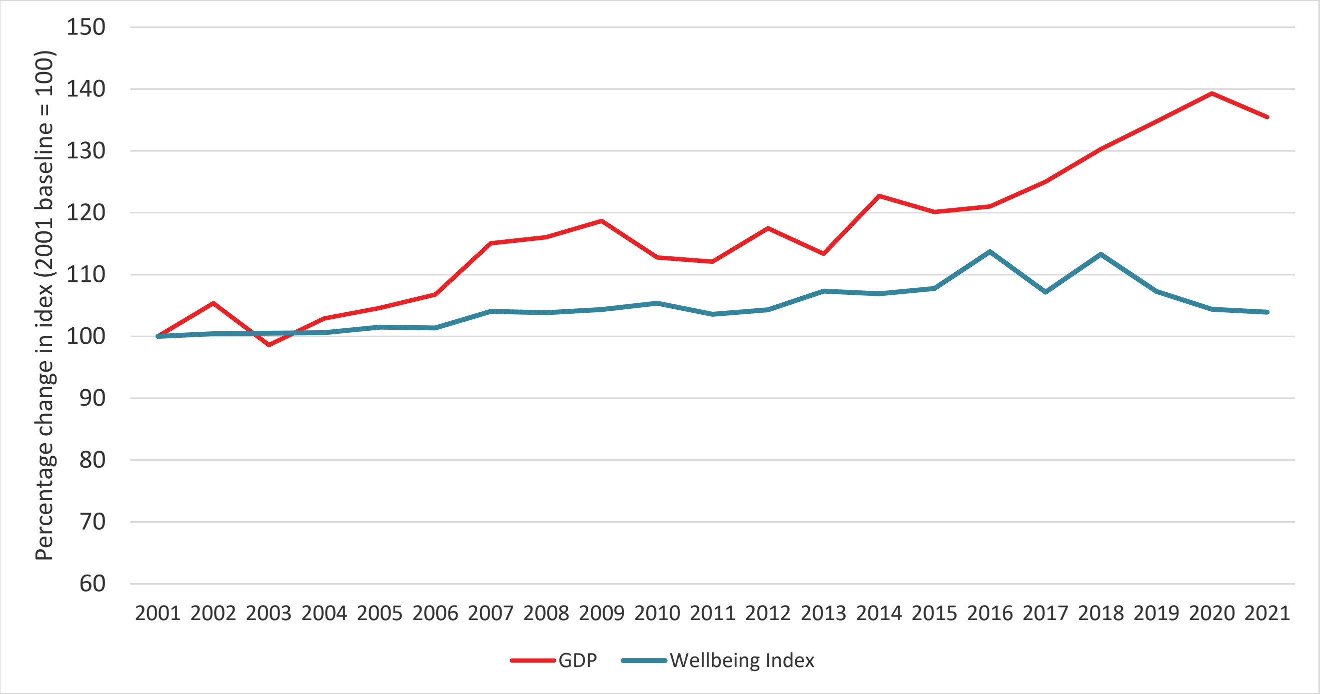


Figure 2: *The diagram above compares changes in the Wellbeing Index (blue line) to Gross Domestic Product (GDP) for the Waikato region over the period 2000 to 2021.*

> *The Wellbeing Index has followed a flatter trajectory than GDP, with a decrease in recent years pointing to a lack of in progress in people's quality of life.*

Back to top

The four wellbeings

Social – involves individuals, their families, whānau, hapū, iwi and a range of communities being able to set goals and achieve them, such as education, health, the strength of community networks, financial and personal security, equity of opportunity, and rights and freedoms.

Economic – looks at whether the economy can generate the employment and wealth necessary to provide many of the requirements that make for social wellbeing, such as health, financial security, and equity of opportunity.

Environmental – considers whether the natural environment can sustainably support the activities that constitute healthy community life, such as air quality, fresh water, uncontaminated land and control of pollution.

Cultural – looks at the shared beliefs, values, customs, behaviours and identities reflected through language, stories, visual and performing arts, ceremonies and heritage that make up our communities.

The primary sector's contribution to GDP and employment has declined over the last 20 years, with job numbers in dairy farming declining some 18 per cent since 2000. The New Zealand dairy sector is trending toward fewer dairy farms, each with larger herds (NZ Dairy Statistics). Dairy farming remains the biggest employer in Waikato's primary sector. Drought was found to reduce employment in the dairy industry, more so than in other primary industries (Bell et al. 2021).

Climate is an important driver for the primary sector (Bell et al. 2021, Bryant et al. 2010). The 2020 drought was estimated to have had a high economic impact on Waikato and Northland in terms of GDP and household income, largely driven by reduced dairy production (Nixon et al. 2021). Prior to that, the 2013 drought was the most severe on record, affecting the entire North Island (Porteous and Mullan 2013). The 2008 drought hit the Waikato hard, with January rainfall the lowest for 100 years. A shortage of feed increased the price of silage to four times its normal rate. The cost of the 2008 drought for agriculture was estimated to be more than a billion dollars. The impact on farm profitability can be direct for dairy farms, however, may be delayed two years after the drought event for sheep and beef farms (Bell et al. 2021; Pourzand et al 2019). Milk solid production per hectare, and per cow, continues to increase for New Zealand as a whole, reaching record highs in 2021 (NZ Dairy Statistics).

> *Milk solid production per hectare, and per cow, continues to increase for New Zealand as a whole, reaching record highs in 2021. .*

Back to top

Waikato Progress Indicators for wellbeing over the last 15 years

▲ Improving trend
▼ Worsening trend
~ No significant change

ECONOMY

▲	**Building activity**	Real value of new building consents issued.
~	**Employment**	Proportion of total working-age population who are employed.
▲	**Income**	Real median weekly household income.
▲	**Regional GDP**	Real Gross Domestic Product (GDP) per capita.
▼	**Water use**	Water allocation as a percentage of primary allocable water (Waikato River).

SOCIETY

▼	**Community engagement**	Percentage of people who agree the public can influence council decisions.
▼	**Community pride**	People's sense of pride in the way their city/town looks and feels.
▲	**Crime**	Rates of victimisation per 10,000 population.
▼	**Cultural respect**	Level of agreement that having people with different lifestyles and cultures makes area a better place to live.
▲	**Educational attainment**	Percentage of school leavers with NCEA level 2 or above.
~	**Housing affordability**	Ratio of housing costs to household disposable income.
~	**Income inequality**	Gini coefficient – a measure of the concentration of income within the region.
▲	**Life expectancy**	Life expectancy at birth.
▼	**Life satisfaction**	Percentage of people who rate their overall quality of life positively.
▼	**Perceived health**	Percentage of people who rate their overall health good, very good or excellent.
▲	**Perceptions of safety**	Percentage of adults who feel safe walking alone in their neighbourhood after dark.
▼	**Physical activity**	Percentage of people who say they were physically active on five or more of the past seven days.
▼	**Public transport**	Passenger transport boardings per resident per annum.
▲	**Road safety**	Social costs of road injury crashes per capita.
▼	**Social connectedness**	Percentage of people who feel a sense of community in their neighbourhood.
~	**Te reo Māori speakers**	Percentage of Te reo Māori speakers in the total population.
▲	**Voter turnout**	Average voter turnout in local council, DHB and regional council elections.

ENVIRONMENT

▲	**Air quality**	Exceedances of the regional guideline for particulate matter.
~	**Coastal ecosystem health**	Traits Based Index calculated for estuarine monitoring sites.
~	**Environmental attitudes**	New Ecological Paradigm – Percentage pro- or mid-ecological.
~	**Greenhouse gases**	Annual total greenhouse gas emissions.
~	**Indigenous vegetation**	Extent of indigenous vegetation on land.
▲	**Recycling**	Self-reported prevalence of household recycling.
▼	**Residential expansion onto highly productive land**	Area of highly productive land in urban and rural residential use.
~	**River water quality**	Percentage of water samples taken from rivers and streams deemed unsatisfactory for ecological health.
▲	**Soil quality**	Percentage of monitored soil sites meeting at least five soil quality targets.
▼	**Waste**	Tonnage of waste to landfill per annum.

Figure 3

Back to top

Wāhanga tuawhā
Part 4

He hītori hurihanga taiao

A brief history of environmental change

Rain and river flows have been measured since the 1950s, and the water quality of our rivers has been routinely monitored since the 1980s. Some sites and attributes have been monitored for 10 years or less, missing significant step changes in the region's environmental history.

Before bringing together results from monitoring programmes (in Parts 6 to 8), a brief history of important changes in environmental management is warranted.

The natural world has transformed rapidly since colonisation, with land moving from the control of hapū and iwi to being mostly owned by individuals, companies and the Crown. Dramatic changes in land use have impacted the environment. These changes have mostly brought about water quality degradation, loss of native forests and wetlands, erosion and sedimentation, and reduction in habitat for taonga species.

As New Zealanders moved away from logging native forest as a primary industry, pastoral development required changes to vegetation, and also to soils and drainage.

> *This report covers a significant period in New Zealand's history, and draws on the full period of records available at the time of analysis (mostly 2021).*

For much of the 20th century, river management focused on floods. Driven by risk to life and property, the building of stopbanks started early in the century, with major works continuing to expand and raise these flood schemes. Stopbanks quickly overflowed when the channel filled with sediment. As flood waters receded, leaving pasture buried under silt and towns people shovelling mud from their living rooms, the connection between flood hazard and soil erosion was clear.

Farmers especially understood the value of soil remaining in place. The Water and Soil Conservation Act, passed in 1967, enabled integrated management of stopbanks in lower catchments with soil conservation in the headwaters.

Soil conservation efforts in the Waikato region included the Waihou catchment control scheme. Steep, eroding land was identified and planted, including blocks of steep land at the foot of the Kaimai Range. By 1997, all targeted areas were retired from pasture.

Back to top

Streams and rivers flowing into Lake Taupō were also fenced and planted during the 1970s and 1980s to protect the light pumice soils that are highly erodible, even on flat land.

Decades before the Water and Soil Conservation Act, trees were planted in the Taupō catchment to use what was seen as waste land. Cobalt deficiency in the volcanic plateau's pumice soils led to bush sickness in cattle. Work was needed during the Great Depression of the 1930s and many hands were put to work planting pine forest, stretching from Kawerau in the Bay of Plenty through to the Taupō catchment.

Sheep farming became the dominant land use for much of New Zealand until the collapse of the wool industry in the 1980s. The change to beef cattle farming on flat and rolling land, and deer in steeper areas, marked a significant change in environmental pressures that predates much of our monitoring data. A cow weighs in the order of 10 times that of a sheep, with a proportional increase in drinking water needs and dung and urine outputs.

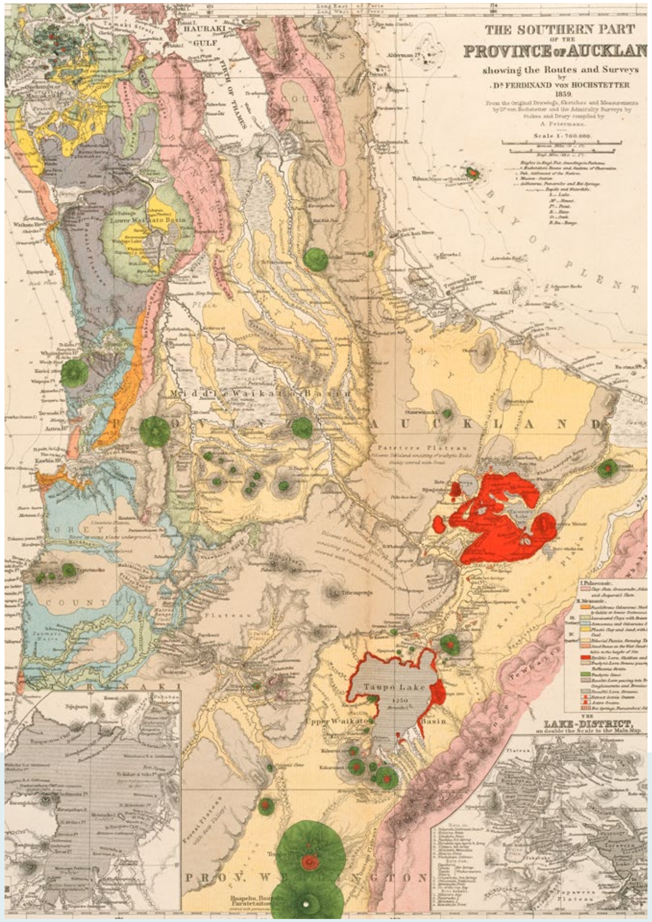
The 1970s and 1980s also saw rising awareness of the degradation of our rivers and lakes. Big industrial cities of the world were dealing with pollution effects such as rivers catching fire from hydrocarbon discharges and mutated fish from toxic waste. In contrast, organic pollution was the main problem for rural communities such as the Waikato.

In addition to urban sewage, a lot of industrial discharges were related to agriculture, including meat works, wool scouring and dairy factories. These discharges were once piped, untreated, directly to rivers used for drinking water. Monitoring river water quality was a new concept, relying on emerging technologies like oxygen sensors. What little data was collected pointed to oxygen sags and high bacteria levels in many rivers (Ministry of Works, 1956; Vant, 2010). The isolated investigations confirmed what people could see and smell.

> *For much of the 20th century, river management focused on floods. Driven by risk to life and property, the building of stopbanks started early in the century, with major works continuing to expand and raise these flood schemes*

Early efforts to tackle water quality problems were limited. For example, raw waste from Hamilton was released into the Waikato River when people were sleeping. Tougher legislation, targeting town sewage and industrial waste for better treatment, was introduced by the Water and Soil Conservation Act 1967 and treatment of raw waste was standard practice by the 1980s.

Energy development was a major driver of change in the Waikato catchment, securing the electricity demands of New Zealand. In the 1970s, coal fired power stations were built in Huntly and Mercer, close to both coal seams and the Waikato River for cooling water. Wairakei, one of the world's first geothermal power stations, has been discharging waste heat to the Waikato River since 1958. The Horahora Station began generating hydropower direct from the Waikato River in 1913, and by 1970 was superseded by eight hydroelectric dams constructed on the Waikato River. Upstream of Lake Taupō, the Tongariro Power Scheme was completed by the Ministry of Works in 1984 and included large diversions from the Whanganui catchment into the Taupō catchment.



Waikato region and surrounding areas in 1859

Some of the earliest flow monitoring was initiated for the design of hydropower schemes. This provided the data to measure many of the profound changes to flow regimes of the Waikato River, including increased low flows and daily peaking to match electricity demand.

Routine water quality monitoring started in the 1980s under the Waikato Valley Authority, Hauraki Catchment Board and others. The big issues at that time included soil erosion and large point source discharges of organic contaminants. The motives for water quality monitoring included improving water quality for swimming and drinking water. The longest running water quality datasets target organic pollution and sediment (such as oxygen, pH, bacteria, nutrients and turbidity).

Land cover monitoring started much earlier, with the Department of Lands and Survey beginning aerial photography in 1936.

In 1989, 40 authorities were amalgamated to form Waikato Regional Council, and monitoring programmes were built on those established by catchment boards, Ministry of Works and others. The Resource Management Act 1991 was then implemented by regional councils, introducing the concept of sustainable resource management, integrated across air, land, freshwater and coasts.

Back to top

Wāhanga tuarima
Part 5

Mātauranga Māori
Indigenous knowledge and practices

Mātauranga Māori is a legitimate source of knowledge to inform council policy and actions, but this report is not intended as a source of Māori knowledge. Mana whenua in the Waikato region maintain their right as kaitiaki, and as the source and orators of their knowledge and aspirations.

Kaupapa Māori Freshwater Assessments (2019) was written at the request of regional councils and territorial authorities across Aotearoa. Councils sought information to aid them in incorporating Mātauranga Māori and wanted to understand the range of tools available and the matters that iwi and hapū considered important around the freshwater environment.

At the time of the above report, seven kaupapa Māori assessment tools were used within the Waikato region.

Taonga species monitoring
A range of tools, methods and approaches to monitor individual species important to iwi.

Cultural Health Index
A seminal Māori cultural monitoring tool that monitors site status, mahinga kai and cultural stream health.

> *This section captures some of the formal tools that hapū use to document and monitor the state of the environment.*

Wai Ora Wai Māori
A framework and digital tool to assess the state of a waterbody from a Māori perspective and which can be adapted to local iwi and hapū views.

Māori environmental performance indicators for wetland condition and trend
A method and set of indicators to assess wetland condition from a Māori perspective.

Mauri of Waterways Kete
A comprehensive assessment of environmental outcomes according to kaupapa Māori.

Waikato River catchment report cards
A means of conveying available (biophysical based) data to iwi and communities.

Mātauranga Māori Knowledge Networks
A project to examine factors affecting river quality from a Māori perspective. It provides a model for iwi and councils wishing to research important aspects for freshwater monitoring locally.

Back to top

> *Seven kaupapa Māori assessment tools are used within the Waikato.*

Other kaupapa Māori assessment tools include:

Mauri Compass
A digital tool covering 12 aspects in three kete: Tangata Whenua, Tāne and Tangaroa. It combines mātauranga Māori with biophysical measurements to answer questions important to iwi and hapū, with results presented in an accessible, visual compass.

Mauri Model / Mauri-o-meter / Ngāti Mākino Model
A tool to assist with decisions around potential engineering projects and their benefit to or impact on mauri.

Cultural flow preference study
A method to assess cultural values and satisfaction for different flow regimes.

Cultural mapping
A tool of various approaches to mapping cultural information and values.

State of the Takiwā
A database and method for cultural and environmental assessments of freshwater environments. It is no longer active but provides useful examples of what is possible.

Significance assessment method
A means of applying cultural values into the RiVAS assessment system (a standardised method to help resource managers grade rivers by relative importance for different uses).

In the *Kaupapa Māori Freshwater Assessments 2019* report, the aspects most commonly used as indicators were:

- mauri
- iwi health and wellbeing
- tikanga and cultural practices
- sites of significance
- fish and mahinga kai species (including availability, presence/absence, abundance and health)
- food safety
- access
- landscape-level habitat and catchment land use
- riparian habitat
- water quality parameters (clarity, pH, temperature, dissolved oxygen etc).

The above aspects cover these areas:

- metaphysical
- cultural and social
- species information
- mahinga kai and ecology
- water quality and habitat.

Monitoring plans that include mātauranga Māori are expected to cover a broad range of matters to meet iwi and hapū aspirations and understandings around what is important.

Back to top

Back to top

Case Study:

Te Ārohirohi o Raukawa Freshwater Assessment Tool

Launched in early 2022, the Te Ārohirohi o Raukawa Freshwater Assessment Tool is an outstanding example of iwi-led freshwater assessment created by our iwi partner, Ngāti Raukawa. The tool works alongside our environmental monitoring at council to directly support Raukawa whānau in assessing the health and wellbeing of their waters.

Te Ārohirohi o Raukawa Freshwater Assessment Tool was developed in collaboration with Raukawa kaumātua, rangatahi and wider whānau through research and a series of wānanga, site visits, testing and feedback. The overarching framework for Te Ārohirohi o Raukawa is the Ngā Mana o Ngā Atua model. Three interconnected spheres – the mana bestowed by atua, ancestral lands and their life-giving mana, and people's mana – provide the foundational framework.

This model has six guiding mātāpono (principles) which connect people and water.

1. **Whakapapa** – Water represents the beginning and sustenance of life. Whakapapa provides the foundation for the unique rights and responsibilities that Raukawa has to water within their takiwā.
2. **Ngā tohu o ngā Atua** – The interrelationship between water, people and the spiritual realm is vital to the health and wellbeing of fresh water. For Raukawa, the assessment of water is to be guided by the signs and symbols from the spiritual and physical realms.
3. **Ngā tapuwae o ngā tūpuna** – Ancestors' footsteps hold essential lessons for understanding environmental management. The mātauranga and experiences of Raukawa ancestors provide critical pathways for restoration and reconnection.
4. **Te reo o te taiao** – Connecting and being in conversation with the environment is critical. Te reo Māori creates an environmental ethic that is holistic, interconnected and enduring.
5. **Tikanga and kawa** – Restoration of Raukawa tikanga and kawa are critical to the health of water and the health of people.
6. **Rongo** – For Raukawa, all senses, feelings, emotions and wairua come into the assessment process.

The four-stage assessment process takes people through a flexible, iterative process flowing from the guiding principles.

1. **Te Kōhae – The approaching light**

This stage is about preparation for what is to come. Planning what is needed, where the assessment will occur, for what purpose, with who and how. It is the promise of the day that has yet to arrive.

2. **Te Uraura – The morning glow**

Research, site visits and wānanga are all critical parts of this stage. This process takes time and is about connection, learning and reflection. The light before dawn reveals some things, but the full light of day will show more.

3. **Te Maruao – The dawn break**

This stage is about visioning and planning. It is here we start to see more clearly the dreams, priorities and plans we have for protecting or restoring a place.

4. **Te Ārohirohi – The glistening of the water from the sun**

The final stage is about defining a plan of action. With the sun glistening down full light, now is the time to get to work.

Te Ārohirohi o Raukawa Freshwater Assessment Tool is a practical tool with diverse applications to support iwi aspirations for healthy waterways. It affords guidance at both strategic and grassroots levels.

The assessment tool can also help to inform freshwater management strategies, restoration plans, and funding applications. Using the tool to assess water supports whānau to reconnect with the environment, practise their tikanga and kawa, and participate in planning and decision making for water.

Te Ārohirohi o Raukawa

Raukawa Freshwater Assessment Tool

Ngā Mana o Ngā Atua Model

1. Ngā Mana o Ngā Atua
2. Nga Mana o Te Whenua
3. Ngā Mana o Ngā Tāngata

Ngā Mātāpono

1. Whakapapa
2. Nga Tohu o Nga Atua
3. Te Reo o te Taiao
4. Nga Tapuwae o Ngā Tūpuna
5. Tikanga
6. Rongo

Freshwater Assessment Process

1. Te Kohae
2. Te Uraura
3. Te Maruao
4. Te Ārohirohi

If you are interested in learning more about the Te Ārohirohi o Raukawa Freshwater Assessment Tool, please contact the Raukawa Charitable Trust (info@raukawa.org.nz).

Back to top

Wāhanga tuaono
Part 6

Te hau
Air

Air is a taonga (treasure) of Ranginui (the Sky father). Connected with hau or hā (wind or breath), the wellbeing of the air in the region is vital to people's sustenance.

Tihei Mauri Ora (the breath of life) was uttered in the creation of the first person by Tāne and is repeated today through karakia and ceremony. Hā is considered a vital essence for people and between people and other living things. In Māori narratives, Tāwhirimātea is the atua who presides over the wind, elements, atmosphere and climate.

Within mātauranga, there are many names for winds, clouds and different kinds of weather. Tūpuna (ancestors) understood these intimately and their various meanings, implications and impacts. Reading the skies was necessary for survival, understanding what the day would bring, and navigating across lands and oceans. Specific clouds, for example, would be used to realise incumbent weather events and plan accordingly. Air covers the skies, winds, clouds and weather, but is also in a constant relationship with the earth. Phenomena such as mist, dew and snow maintain the relationships between Ranginui and Papatūānuku (the Earth Mother).

The Waikato region enjoys good air quality for most of the year. As an island amid a large ocean, the prevailing winds deliver clean air to Aotearoa. But air pollutants can become trapped close to the ground by temperature inversions that form on cold, still days. The result is poor air quality at times during winter, particularly in towns with more smoke from wood fires, traffic emissions and industrial discharges.

Particulate matter less than 10 micrometres in size (PM_{10}) can affect human health. Monitoring PM_{10} also provides an indicator of other air pollutants from wood and coal burners used for home heating.

However, monitoring even finer particles ($PM_{2.5}$) is now recognised as a better indicator of pollutants affecting human health. Monitoring $PM_{2.5}$ also presents less risk of natural elements, such as sea spray, triggering exceedances because of the larger size. Monitoring of $PM_{2.5}$ has recently commenced, however, the longer record of PM_{10} measurements remains useful for understanding long term trends in air quality.

The air quality of the Hamilton, Te Kuiti, Taupō and Putāruru airsheds complied with National Environmental Standards (NES) in 2020. This is an improvement for Te Kuiti and Taupō, largely attributable to reduced emissions from home heating sources. The Tokoroa airshed is also improving, however, it has not met the NES and World Health Organisation guidelines for PM_{10} and $PM_{2.5}$. There is some evidence of arsenic and lead contamination from the burning of treated and painted wood in Tokoroa.

The last breach of the PM_{10} standard in Hamilton was in 2013 (24 hour standard from NES). Since then, both the 24 hour average and annual average PM_{10} concentrations have complied with the NES and World Health Organisation guidelines. However, some of our previously compliant

Back to top

airsheds will become non-compliant if New Zealand introduces standards for $PM_{2.5}$ to align with recently updated World Health Organisation guidelines.

Wood burners for domestic home heating were identified as the main source of poor air quality in most airsheds. In the Hamilton airshed, busy traffic routes and intersections have contributed to localised air quality problems. Exhaust emissions include fine particulate matter, volatile organic compounds (such as benzene), carbon monoxide and nitrogen oxides (referred to as NOx). In Hamilton, benzene concentrations have been improving since 2003, and the one hour average nitrogen dioxide concentrations have met the NES one hour standard since 2011.

However, 2021 World Health Organisation guidelines set lower values for nitrogen dioxide, and these were exceeded at the nine passive air monitoring sites in Hamilton maintained by Waka Kotahi NZ Transport Agency. There were also exceedances at sites in Taupō, Te Awamutu and Cambridge. Trend analyses undertaken for the 12 passive nitrogen dioxide sites monitored by Waka Kotahi has identified only one site in Hamilton with a worsening trend and five sites with an improving trend (four in Hamilton and one in Te Awamutu).

> *The interdependencies between the air, climate and skies with the earth, plants and animals must be considered.*

Improvements to air quality were observed during the first COVID-19 lockdown in 2020. Compared to the April average for the previous four years, April 2020 PM_{10} averages indicated reductions of 15 per cent to 37 per cent for Morrinsville, Hamilton and Te Kuiti. No reductions were observed in the other four monitored airsheds. A 40 per cent to 50 per cent reduction in nitrogen dioxide concentrations for April 2020 was observed at all nine Waka Kotahi NZ Transport Agency monitoring sites in Hamilton, as well as in Cambridge and Taupō.

Transport is also a source of greenhouse gas emissions, estimated at 15% of total emissions for the Waikato region (Envirostrat, 2020). Electricity generation was close behind at 13%. Agriculture was the largest contributor to the total gross emissions for the Waikato (69%). Forestry removed 44% of the total emissions. Not accounted for in these estimates are emissions from drained peat and other organic soils (see Part 7), which will be assessed in a supplementary technical report for the 2023 inventory.

Greenhouse gas emissions have raised global temperatures, with carbon dioxide concentrations rising some 20 per cent since 1980, as measured at Baring Head, Wellington. The atmosphere itself retains little heat. Instead, greenhouse gases reflect heat back into our oceans and rises in ocean temperature then drive the weather systems we experience on land. Sea surface temperatures at Waikato latitudes have recorded increases of around 0.2 ° Celsius per decade, warming faster than the Southern Ocean (StatsNZ).

Tangata whenua in the Waikato region are concerned about air contamination's health effects and emissions' climactic impacts. There are concerns about air pollution's effects on the mauri of te hau. These impacts stretch beyond the skies and reach into customary resources, ceremonies and practices that require the skies, and the spiritual values of other taonga. The interdependencies between the air, climate and skies with the earth, plants and animals must be considered.

Wood burners are the main contributor to **wintertime** PM_{10} **exceedances**

Back to top

Wāhanga tuawhitu
Part 7

Te whenua
Land

Hineahuone, the first woman created within Māori cosmologies, was made from the earth, Papatūānuku (the Earth Mother). For Māori, all things begin and end with the whenua. We are born from the land, and upon death, we return to the land. When babies are born, the whenua (placenta) is returned to the whenua (land), establishing a reciprocal connection between people and the land.

Reflected in the unique roles of tangata whenua (people of the land) and mana whenua (authority that comes from the land), Papatūānuku provides a sense of intergenerational identity and belonging. For Māori, land is all encompassing and includes everything on, in and under it. All natural elements are interconnected and interdependent, existing seamlessly together.

Māori built an intimate and deep knowledge of soil, wetlands and forests, reflected in Māori place names that indicated an area's land and forest types. Iwi and hapū understood how to use land to grow food and medicines, cook and make art (for example using kōkōwai/red ochre). Kaitiakitanga and tikanga provided land management systems prioritising the interdependency of people and the land, establishing foundations for sustainable food and medicines, cultural identities and spiritual sustenance.

Transformations to land in the region have been significant and ongoing. Land was moved from collective Māori control and management into public and private land holdings, and was used for agriculture, forestry, urban growth and industrial development. Land modification and intensification, along with poor regard for the interdependencies between land, water and other taonga, have all led to land and waterway degradation.

Most land in the Waikato region is used for pastoral farming (53 per cent), followed by indigenous vegetation (27 per cent) and plantation forestry (12 per cent). The remainder is horticulture and cropping (1 per cent), urban areas (1 per cent), or other uses (5 per cent).

Different land uses place different pressures on the environment. When land use changes to a more intensive use – from forestry to pasture, or pasture to urban – pressures on land and water also intensify.

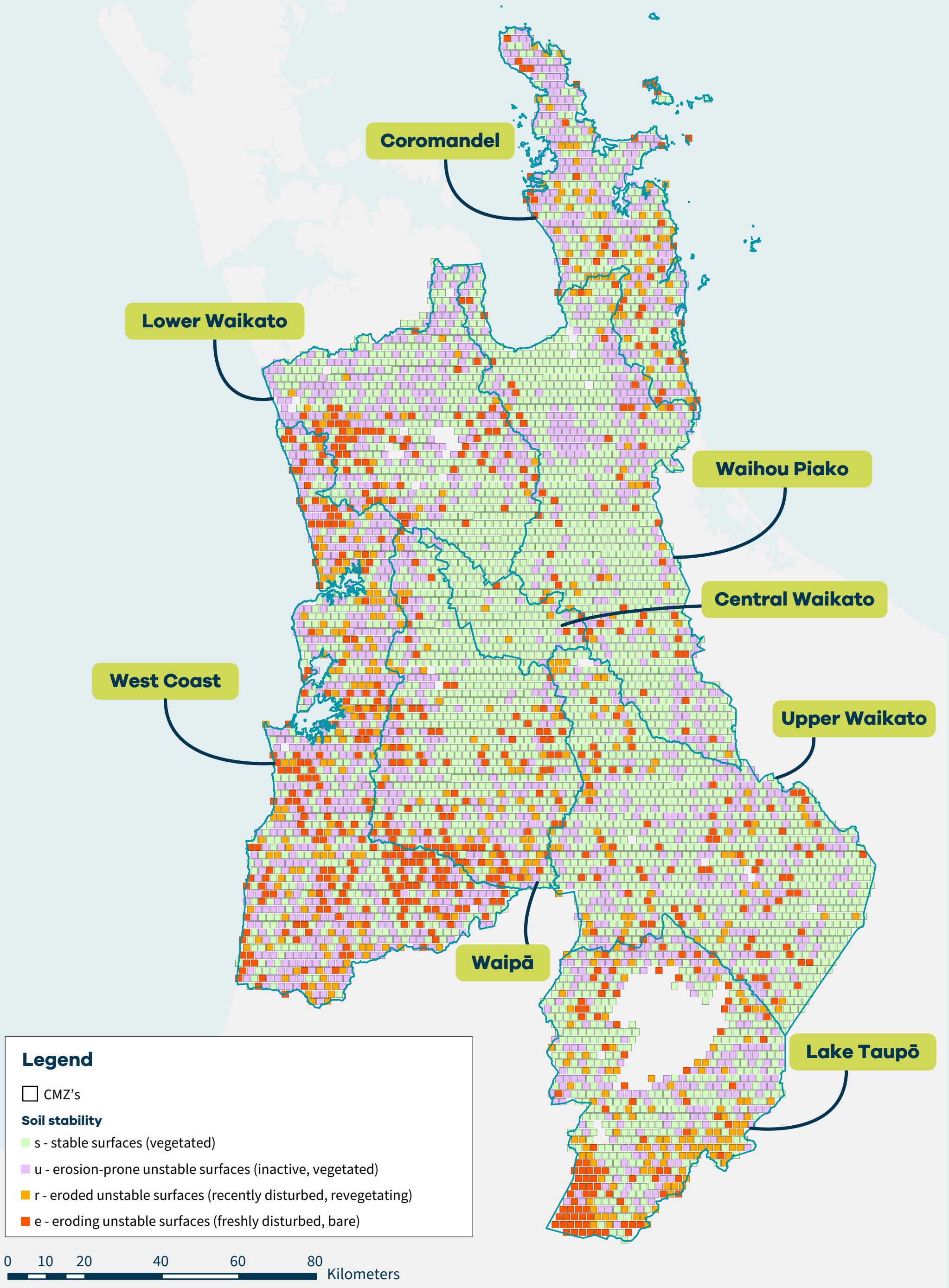
From 2001 to 2018, pastoral land in the Waikato region increased in area by an estimated 41,527 hectares due to the net conversion of planted forest. By far, the greatest area of net conversion of planted forest to pastoral land occurred in the upper Waikato. In contrast, the neighbouring Taupō area had the region's greatest conversion of pasture to forestry, where land use was regulated to protect Lake Taupō.

> *Pastoral intensification was greatest in the upper Waikato area.*

Land use intensification increased across the region between 2001 and 2018, mainly driven by dairy conversions. An estimated 504,335 hectares (40 per cent) of pastoral land underwent some intensification during this period. De stocking occurred on 280,921 hectares, giving a net intensification on 17% of pastoral land for the region. Pastoral intensification was greatest in the upper Waikato area.

Erosion can impact soil productivity and ecosystem services, limiting the land's range of potential productive uses. Erosion also significantly affects waterbodies, from streams, rivers and lakes to estuaries and coasts. Increased fine sediment in water can decrease its clarity, degrade aquatic habitats and impact recreation, fisheries and domestic water supply.

Back to top



Back to top

Erosion

The West Coast Freshwater Management Unit has many unstable eroding surfaces, shown as red dots on this map. Points were surveyed from 2017 aerial photographs, recording erosion at the intersection at points on a 2x2 km grid.

In a 2017 aerial survey, 49 per cent of land surveyed was stable (no evidence of erosion), 26 per cent was unstable (erosion prone, inactive) and 17 per cent was recently or currently eroding (Figure 4).

Land use related activities were the major cause of soil disturbance at 21 per cent of the points surveyed in 2017. In particular, farm and forestry tracks were the dominant disturbance feature, and also made up 68 per cent of land use disturbance observed in the region.

> *On dairy farms, the tracks and laneways made up 77 per cent of bare soil, compared with 37 per cent on drystock farms.*

Dairy and drystock farm tracks and laneways are of particular concern. They provide a potential sediment source, as well as a transport mechanism for nutrient and faecal material from critical source areas to enter waterways. On dairy farms, the tracks and laneways made up 77 per cent of bare soil, compared with 37 per cent on drystock farms.

This highlights the importance of managing farm and forestry tracked areas carefully to minimise contaminant transport to waterways. Correct management, such as appropriate stormwater management and ensuring adequate buffer zones between tracks and waterways, is essential for mitigating sediment and nutrient losses.

Stock accessing waterways can erode streambanks, causing sediment to enter waterways, and can directly contaminate water with faeces, impacting water quality, aquatic habitats and recreational and domestic use of water.

Back to top

Fencing and planting of riparian zones is carried out to improve water quality and increase biodiversity.

The council started quantifying the proportion of riparian fencing in the region in 2002, and updates this figure every five years. The proportion of fenced bank length of waterways in pastoral land increased from 28 per cent to 61 per cent between 2002 and 2017. However, the amount of woody riparian vegetation did not change significantly over the same timeframe.

In 2017, land used for dairy had a much greater proportion of fenced bank length than for drystock (87 per cent compared to 36 per cent). Since 2002, the proportion of fenced bank length had increased significantly for dairy (3.1 per cent increase per year), but not for drystock (1.3 per cent increase per year).

Land use and management practices also affect soil quality: the physical, chemical and biological properties of soil. Five yearly monitoring of soil quality targets shows a significant increase in sites meeting at least five of seven targets between 2014 and 2021 (a rise from 77 per cent to 92 per cent), and that most of the region's soils (80 per cent) are of satisfactory quality for their current use.

However, soil quality is 'of concern' on about 18 per cent of pastoral farming land, mostly due to soil compaction and excessively high soil fertility on some dairy farms. Both these factors can negatively impact water quality. Pugging and compaction of soil impair drainage, potentially increasing runoff to waterways, and excessively high soil fertility increases the risk of nutrient losses to waterways.

In 2018, 27 per cent of the region's land area was covered in indigenous vegetation. Different types of covenants can be used to protect land: QEII covenants for private land, while Ngā Whenua Rāhui kawenata offer covenants for Māori land. Between 1996 and 2022, the area of land protected by QEII covenants increased from 4608 hectares to 15,223 hectares, and land protected by kawenata increased from 903 hectares to 15,695 hectares. However, the rate of increase has slowed since 2005 for QEII and since 2010 for kawenata.

Most protected areas are in some form of natural cover, mainly indigenous forest (78 per cent), followed by scrub and shrubland (17 per cent), with bare or lightly vegetated land and sedgeland each at 2 per cent. These estimates do not include the area of forest that is afforded some protection as Significant Natural Areas (SNA) under district plans. The category of indigenous vegetation experiencing the greatest decline, was scrub and shrubland with a net loss of 2,289 hectares between 2001 and 2018.

The remaining area of freshwater wetland was 33,268 hectares in 2018. This is a fraction of the historic extent, representing a third the area of pre-European herbaceous freshwater wetland. And it represents 8% of pre-human freshwater wetland, including Kahikatea and other woody vegetation. The Waikato has about 18,500 hectares of undrained peatlands, which are a taonga for iwi, provide habitat for threatened flora and fauna, and can act as carbon sinks in their natural state. Drained peatlands (65,400 hectares) also provide considerable economic value to the region and are used to grow pasture, mainly for dairy cows. Peat drainage results in ongoing breakdown of the peat, causing land subsidence and significant greenhouse gas emissions.

Subsidence and eventual loss of peat increases the risk and frequency of flooding, inundation and ponding. Upgrade, repair or installation of drainage and other infrastructure such as flood protection, pumps, roads and utilities are required to deal with these effects, increasing costs for landowners in those areas.

Climate change, including increasing soil temperature, decreased rainfall and lower groundwater levels during summer, could increase peat subsidence rates. Sea level rise in combination with subsidence on the Hauraki Plains could also increase the risk of inundation and flooding.

Land use in the Waikato

53%	**pastoral farming**
27%	**indigenous vegetation**
12%	**plantation forestry**
2%	**horticulture and cropping**
1%	**urban areas**
5%	**other uses**

Back to top

Back to top

Case Study:

Bringing Tūī back – the Hamilton Halo Project

The Hamilton Halo project was initiated to help bring native birds back into Hamilton city. At the time tūī were notably absent or, at best, a rare sight in the city. Now, 16 years later, tūī are not only a common sight but many stay to breed within city limits. Highly valued by people living in Hamilton, tūī were a key species for the project. Many other native species are hoped to have benefited from the pest control.

Initiated in 2007 by Waikato Regional Council, in conjunction with Manaaki Whenua Landcare Research, success in bringing back tūī back reflects on the many other organisations and community groups who have supported this recovery of biodiversity.

Tūī are both important pollinators and dispersers of native plants' seeds. The tūī was chosen as a project focus because viable breeding populations exist within the 20 kilometre winter feeding range of the bird. Research from Manaaki Whenua showed that, unlike other wildlife, tūī do not need corridors and are known to commute into the city to feed on the abundance of exotic plants such as camelias. Small numbers of tūī were tracked returning from the city to rural summer nesting forest remnants outside the city. Small numbers of tūī visited Hamilton every year between May and August, with more seen in the western suburbs. However, tūī were not staying in Hamilton during the breeding season.

Baiting operations to control possum and rat numbers were established at a handful of forest remnants within 20 kilometres of the city limits. Rat and possum numbers are severely reduced in the winter and early spring to give the native birds a better chance of breeding successfully the following spring/summer.

The pest control method or 'recipe' is a crucial component of the Hamilton Halo project to keep the cost of running the programme sustainable. Halo sites receive pest control three years in a row before having two years without control, and the focus is on intensive control of rats as they are the key predator of tūī and other native forest birds. In the last two years, two sites have been moved onto an annual control cycle, meaning the pest rat and possum populations don't have a chance to recover between control cycles.

While rats are the main target species, a co-benefit of the work is that possum numbers are also dramatically reduced, which both assists bird breeding success as well as improves the forest health through reduced leaf browsing.

As the bird numbers flourish in these protected forest remnants around the city, they spill over into the surrounding landscape, including into the urban areas of Hamilton and Cambridge.

The success of Hamilton Halo to bring tūī back into the city, has prompted thinking to start Phase II of the project. Although in its infancy, the intent of Phase II is to continue and build upon the success of Hamilton Halo.

Wāhanga tuawaru
Part 8

Te wai
Water

In Māori pūrākau, all things begin with water, from the amniotic waters of the whare tangata (womb) to the first waters from the tears of Papatūānuku when separated from Ranginui. Fresh water as we know it today began through the union of Tāne te Waiora (Tāne of the life-giving waters) and Hinetūparimaunga (atua of the mountains), and then came Parawhenuamea, the personification of fresh water on land.

There are different names for the states of fresh water, and names and states for other bodies of water, flows and features. Mātauranga Māori about wai is as vast as the oceans. The waters of the moana (oceans) are also vital to people. Taonga species gifted by Tangaroa (atua of the sea) depend on healthy ocean ecosystems and the relationship between land, fresh water and the seas.

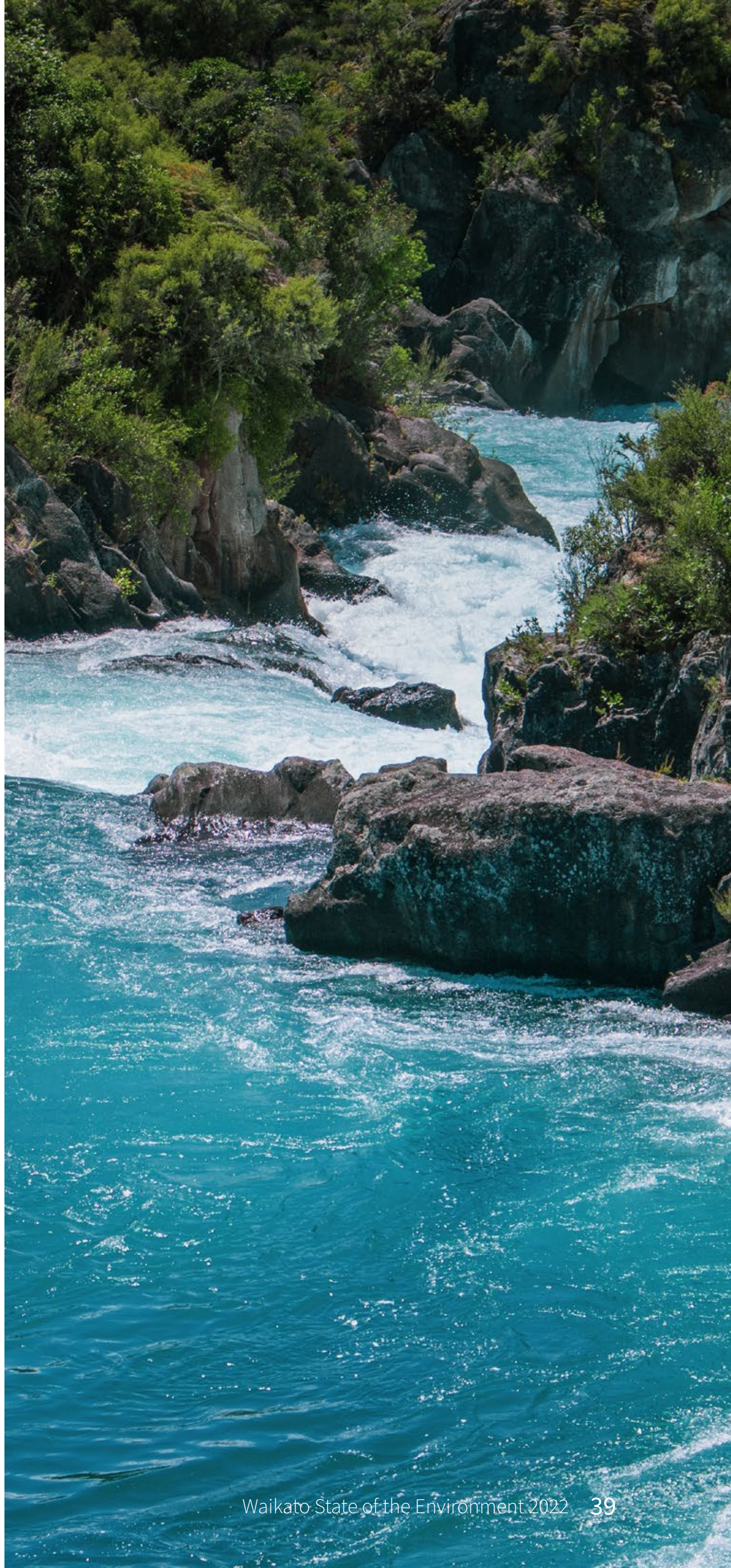
Waikato Regional Council monitors water, from river flows to water chemistry and aquatic ecosystems.

There has been a marked reduction in water quantity over the last 30 years. Rainfall has decreased across the region, with Coromandel area rainfall declining 30 per cent from 1960 to 2020. The last decade has seen declines in summer rainfall across the region, and eastern areas also experienced declines in spring rainfall. Reductions in rainfall were compounded by an increase in potential evaporation, resulting in reduced river flows.

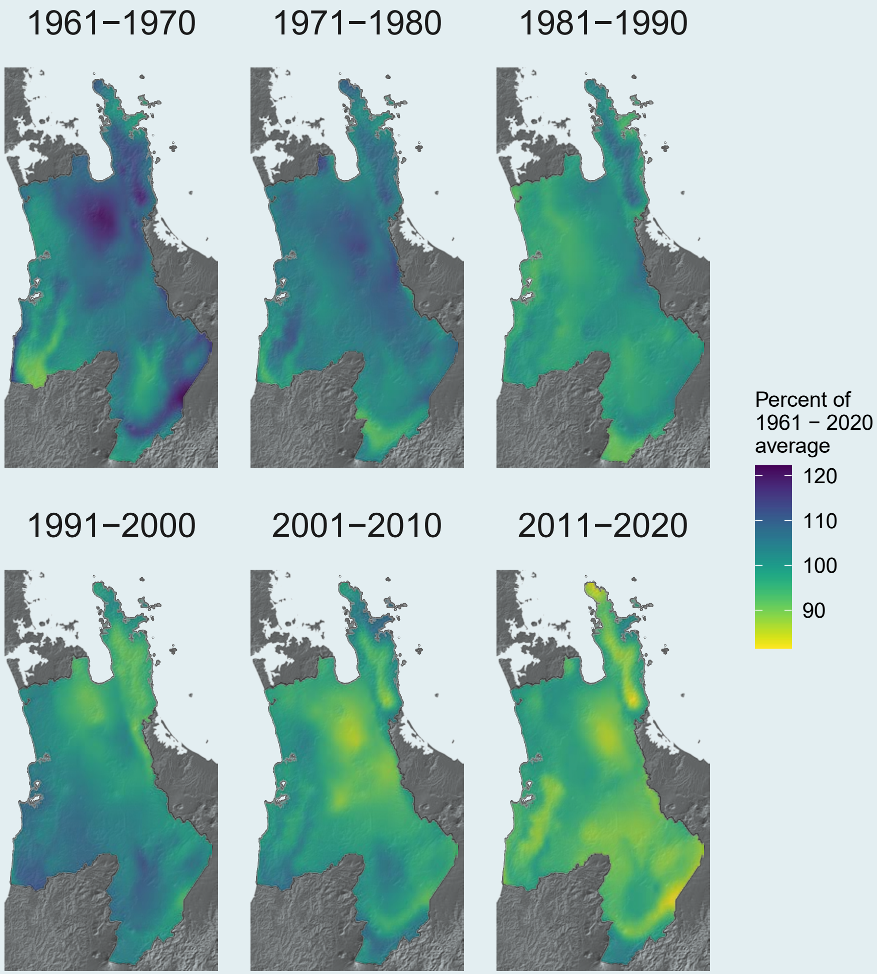
Local events punctuate the ecosystem impact of these reductions. For example, Lake Kimihia near Huntly completely dried out in 2020. In streams near Tūākau, fish kills were caused by exposure of acid sulphate soils when the water table receded during prolonged drought.

Agriculture was the biggest abstractive user of water over the period of record, including irrigation and other uses on farm. The municipal takes for Auckland increased in 1998, adding a direct water take from the Waikato River to the many tributary diversions Auckland already had in place. The additional take represented a step change in total water use for the Waikato region, and one with no return flows. Other large increases in water use occurred between 1995 and 2005, including municipal, industrial and agricultural takes. Since 2010, most of the increase has been in agricultural use, retaining the position as the largest category of water use.

The Waikato River has historically seen marked increases in summer flow because of hydropower schemes. The Tongariro power scheme diverts water from the Whanganui River into the Taupō catchment. Water storage, including the control gates on Lake Taupō, enables high outflows to continue for a period after inflows decline. This storage comes at a cost, with evaporative losses from Lake Taupō averaging 25 cubic metres per second, which exceeds all water takes for towns and farms in the Waikato catchment.



Back to top



Reduced rainfall

The 2011-2020 decade recorded the lowest average rainfall, compared to previous decades, and this is pronounced in the Coromandel Ranges. This map uses NIWA's virtual climate station network to predict rainfall between rainfall recorders at different elevations. The region is shaded according to the per cent of the long-term average rainfall (1961-2020), with yellow representing lower rainfall than average.

Back to top

> *Increases in nitrogen were detected at nine of the 10 monitoring sites on the Waikato River mainstem.*

There were improving trends for phosphorus in our rivers between 1990 and 2020, with both total phosphorus and bioavailable dissolved reactive phosphorus decreasing over this period. This significant achievement was associated with reduced algae in the Waikato River (measured as chlorophyll-a). Phosphorus is a plant nutrient and can support excessive plant growth (such as algae blooms).

The validity of the observed trend is brought into question by changes to the way phosphorus was measured in the laboratory. However, there are several lines of evidence supporting a real reduction in phosphorus, including reduced algae growth, a reduction in phosphorus levels reported from other regions (McDowell at el. 2019), and reductions in phosphorus inputs from wastewater.

Several major point sources, including Hamilton's wastewater treatment plant, recorded declines in the load of phosphorus discharged to the Waikato River. The move to land disposal of washdown water from dairy sheds is expected to reduce phosphorus discharges, as soils can capture the solids to which phosphorus is bound and put it back into growing pasture.

Alongside declining phosphorus, the concentration of ammonia declined at half of the monitoring sites. Ammonia is an indicator of large inputs of anoxic water, such as organic waste, which is rapidly converted to nitrate in well oxygenated rivers.

Better management of agricultural soils may have contributed to the improvements in stream water quality. Average soil phosphorus levels (measured as Olsen P) may not have changed significantly, but the number of monitoring sites with excessively high soil phosphorus decreased. Better land management by the minority of landowners who were applying excessive fertiliser could be a contributing factor to the water quality improvements.

Erosion of fine sediment also contributes phosphorus to waterways. Most phosphorus is transported with the sediment it binds to, or as a component of organic matter. We did not detect widespread declines in sediment in rivers (measured as turbidity, suspended sediment and black disc water clarity).

Bacteria is transported with fine sediment, and both sediment and bacteria remain at high levels in many rivers. Using water clarity as a measure of sediment, 50 per cent of river sites were below the National Policy Statement for Freshwater Management 2020 (NPS-FM) national bottom line for black disc. Also, 68 per cent of sites were the worst band for *Escherichia coli*. This bacterium is not generally harmful, but is a useful indicator of faecal contamination that may contain pathogens and pose a risk for contact recreation.

Unlike phosphorus, nitrogen concentrations continued to increase in many rivers. Nitrogen, like phosphorus, is a major plant nutrient. Increases in nitrogen were detected at nine of the 10 monitoring sites on the Waikato River mainstem (all except Taupō gates). The biggest increases were in the upper Waikato, where all tributaries between Taupō and Karāpiro recorded worsening trends for the period 1990 to 2020. Cropping areas, including Pukekawa and Pukekohe, exhibited increasing nitrate at nine of 11 monitoring wells, and streams in this area also reported increasing nitrogen.

In contrast, all monitoring sites in the Piako catchment were improving or had no significant change in total nitrogen. In the Hamilton basin, nitrate decreased at 11 of the 12 monitoring wells from 2003 to 2020, and streams in this area were also generally improving.

Many of our riverine and peat lakes have ‘flipped’ from aquatic plant dominated to algae blooms, which is a symptom of eutrophication. The displacement of native plants and fish, replaced by algae and invasive fish, represents a loss of biodiversity and ecosystem health. Reports of fish kills are now frequent on lakes Ngāroto and Hakanoa. Wind normally keeps these lakes well oxygenated because mixing is rapid when the water is only a few metres deep. One of the consequences of excess nutrients (these lakes are hypertrophic) is that it only takes a few weeks of calm, hot weather for oxygen to be depleted by decomposition of such a high biomass of algae. High temperatures and low oxygen are a lethal combination for fish because their oxygen requirements increase with temperature. The carcases of dead fish then feed bacteria that kill birdlife (avian botulism).

Most monitored lakes fail to achieve the national bottom lines for compulsory attributes in the NPS-FM. However, there have been recent signs of improvement for several lakes. The Trophic Level Index (which combines several NPS-FM attributes) has improved over the last three years for six of the 12 lakes with long term monitoring data. Lakes Waahi and Serpentine North recorded their best Trophic Level Index to date in 2022. Lake Serpentine North is a peat lake with moderate nutrient levels (classed mesotrophic), diverse zooplankton and ‘excellent’ aquatic plant communities.

Back to top

But the water quality of Lake Waikare has continued to decline. It is one of only two lakes (of the 12 with long term data) to show an increase in phosphorus in the last five years. Lake Waikare stands out as our most polluted lake. It is now rated as hypertrophic, placing it at the opposite end of the spectrum to oligotrophic lakes like Taupō.

The water clarity of Lake Taupō remains high, often exceeding 15 metres. The targets for returning the lake to a water clarity baseline, set at the 1999 to 2003 average, are being met. Nitrogen concentrations in lake tributaries have increased, however, the rise is levelling off in streams with older water and is already declining in streams with younger water. The removal of nitrogen from deep groundwater via denitrification was higher than budgeted, and has contributed to the earlier achievement of targets.

Estuaries were moderately healthy or good at 13 of the 15 sites monitored (Whaingāroa, Firth of Thames, Tairua), with two sites in poor health. However, many indicator taxa and sediment properties were declining over the 2001-2018 period. Animals living on the bed of estuaries are particularly sensitive to being smothered by deposited sediment and indirectly to increasing nutrient inputs.

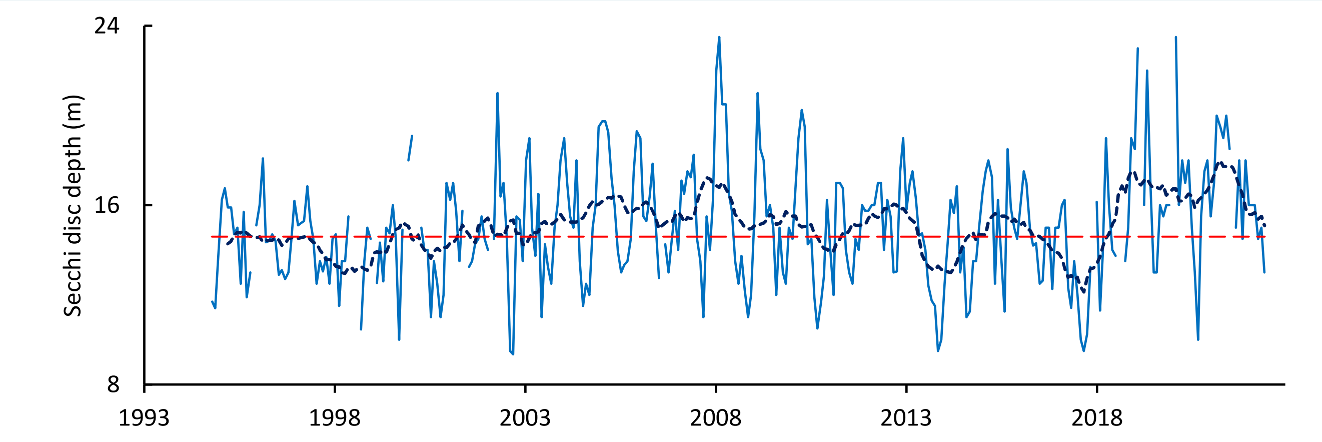
Many streams of the Waikato region are failing to meet national bottom lines for ecosystem health. More than 50 per cent of streams in developed catchments scored in the worst band for the MCI (Macroinvertebrate Community Index). Contributing to the impact on stream invertebrates is deposited sediment, which can smother animals living on the stream bed. The QMCI (Quantitative MCI) is twice as likely to be in the worst band when deposited silt covers more than 20 per cent of the stream bed. More than half of the monitoring sites exceeded 20 per cent deposited silt.

Invertebrates that are most dependent on abundant oxygen are given high taxa scores for the MCI. When organic loading is high, and reaeration is inadequate, these high scoring taxa are the first to be lost from the stream. Low gradient streams are more likely to be depleted in oxygen due to low water velocities limiting reaeration, especially when flows are low. Loss of biodiversity for invertebrate communities has been pronounced in our developed lowland streams. The period of record revealed little improvement in invertebrate indices. Reductions in ammonia and phosphorus have not translated to improved MCI scores.

> *The displacement of native weed and fish, replaced by algae and invasive fish, represents a loss of biodiversity and ecosystem health.*

Back to top

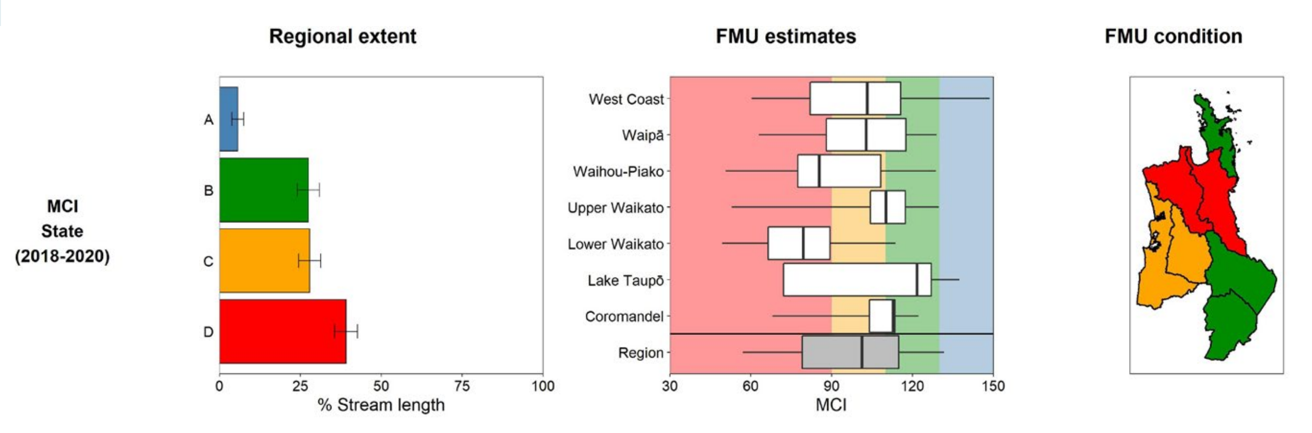
Taupō water clarity



The target for returning the Lake Taupō to a water clarity baseline of 14.6 metres (dashed red line), is being met. Measured clarity is shown as a solid blue line, with a 12-month moving average of those results shown as a dashed black line.

Stream invertebrates

Sensitive insects like mayflies will persist in streams only if habitat and water quality is adequate for survival. So invertebrate communities tell us about prevailing conditions, and are scored using the MCI. Areas are coloured blue for best to worst in red (NPS-FM attribute bands).



Back to top

> *Parts of the region with good ecosystem health include forested catchments with high connectivity to the sea.*

Parts of the region with good ecosystem health include forested catchments with high connectivity to the sea. For example, Coromandel streams have more diverse freshwater fish communities. Access for whitebait to streams further inland can be cut off by waterfalls. Three native fish have managed to adapt to being cut off, with common bully, koaro and smelt using Lake Taupō to complete the larval stage of development. Salmonids that do not migrate to the ocean are called trout, for which Taupō supports a world class fishery. Streams flowing into Taupō also support diverse macroinvertebrate communities.

Abstraction of geothermal fluid for electricity production has continued to increase in the Waikato region. New Zealand's geothermal production has doubled since Waikato and Bay of Plenty implemented their sustainable geothermal policies. Newer power stations reinject geothermal fluid to the ground but Wairakei, the first geothermal power station constructed, continues to discharge geothermal fluid to the Waikato River. Improvements in this discharge have enabled a reduction in arsenic in the Waikato River, however, levels remain high enough for communities to rely on water treatment plants to reduce arsenic levels to below drinking water limits.

Modifications to waterways through damming, irrigation, draining of wetlands and the pollution of fresh water and salt water have significantly impacted iwi and hapū. Flooding of wāhi tapu, reduction in water quality, impacts on mahinga kai and taonga species, detrimental impacts on mauri and interruptions to water-based rituals are impacts felt across generations.

Wāhanga tuaiwa
Part 9

He kōtuinga
Synthesis

The last 30 years has been a time of significant change and growth in the Waikato. This section brings together the domains of air, land and water to better understand the interaction between drivers, pressure and state. It also connects past and present observations, to better understand the observed changes over time and to inform the next chapter on recommendations for management response.

Since intensive dairy farming began expanding in the 1990s, the Waikato dairy herd has increased by some 50 per cent. In many areas, dairy herds have replaced beef cattle, and conversion of pine forest to dairy ramped up during the 2000s. This change is as important as the shift away from sheep grazing in the 1980s. The sheep population has dropped to under a third of pre-1990 levels.

Urban development also increased, with the number of people living in the Waikato region growing from 380,823 at the 2006 census to 458,202 at the 2018 census. Rising sea levels are placing pressure on urban and rural land around the coast. Urbanisation poses many challenges to our natural resources. Our most productive soils, including nationally-significant vegetable growing areas around Pukehohe, are at risk from urbanisation.

Less water

Climate change and increased water use have contributed to lower river flows. The marked decline in rainfall and river flows over the last 25 years has critically impacted people and ecosystems. The drought of 2020 saw lakes such as Kimihia dry up and fish kills on the Hauraki Plains. Dryer soils have affected pasture growth and farm productivity.

Many farmers have invested in irrigation to see them through dry periods, and water takes for irrigation have increased over the last 30 years. Water takes from the Waikato River have also increased to support population growth in Hamilton and Auckland.

Water and energy security are inseparably linked. Moving water over long distances to dry areas is energy intensive. Electricity generation in the Waikato depends on ample water, directly for hydroelectric generation, or indirectly for cooling water at fossil fuel and geothermal generation plants. When hydroelectric generation is reduced by drought, fossil fuel use increases.

Back to top

Back to top

Less phosphorus in waterways

Despite our growing population generating more wastewater, the load of contaminants to rivers from large point source discharges has decreased. Hamilton's discharge of phosphorus to the Waikato River has reduced over the last 20 years, but not all communities have been able to achieve such improvements. Understanding the complex and changing waste streams arriving at treatment plants and adapting plant operation accordingly is an ongoing challenge for plant operators.

The rural sector has also been tackling point source discharges. The cumulative effects of washing down many milking sheds, twice a day, has long been an issue in the Waikato. Farmers have tackled the problem by building treatment ponds and irrigating effluent onto paddocks. State of the environment monitoring has revealed their efforts are working; the decline in ammonia and phosphorus at most river monitoring sites is consistent with widespread reductions in effluent discharges.

The mainstem of the Waikato River is large enough to support algae drifting as phytoplankton. Hydroelectric dams slow the passage of water, extending the time algae can use available nutrients to grow before flowing into the ocean. The council monitors drifting algae in the Waikato River by measuring the green plant pigment, chlorophyll. Chlorophyll levels have improved, coinciding with reduced phosphorus concentrations in the Waikato River. This is an important improvement – algae blooms threaten ecosystems, drinking water supply and recreation.

More nitrogen in waterbodies

Diffuse nitrogen, highlighted as a problem in previous water quality reports, has continued to worsen in many waterbodies.

In horticultural areas (such as Pukekawa and Pukekohe), increases in nitrogen were detected in monitoring wells and streams. All monitored tributaries of the Waikato River from Taupō to Karāpiro also recorded worsening nitrogen trends for the period 1990 to 2020. This area also experienced the greatest pastoral intensification, with land cover changing from pine forest to dairy pasture. Urine patches and fertiliser applications are not entirely captured by pasture grass and the excess nitrogen travels to streams via groundwater; and narrow strips of riparian vegetation fenced from livestock cannot take up all the surplus nitrogen.

Conversely, nitrogen concentrations have decreased in some areas where dairy farming is long established. For example, most monitoring wells and streams in the Hamilton basin have recorded decreasing nitrogen concentrations.

In deep aquifers that lack oxygen, denitrification can eliminate nitrate from groundwater. Thus, increasing nitrogen in streams would be driven by shallow groundwater pathways where there is little denitrification. Understanding the groundwater pathways that determine nitrogen concentrations in streams improves our understanding of where land use controls will be more effective in achieving nitrogen targets for receiving waters.

Deteriorated shallow lakes

By 2000, many of our shallow lakes had ‘flipped’ from aquatic plants dominated to algae blooms, fuelled by nutrients and sunlight. Phosphorus is generally a better correlate of annual biomass of algae than nitrogen, but at times more nitrogen will fuel algae growth. More recent inflows of nitrogen, in addition to historic phosphorus inputs that can be recycled from the lake sediments, make lakes one of our most sensitive receiving environments for nutrients.

Lake Waikare has now reached hypertrophic status, demonstrating that the water quality of our most degraded lakes can decline further. Intense blooms of an orange-coloured algae called *Monoraphidium* have persisted, in addition to potentially harmful cyanobacteria. Livestock density in the Waikare catchment has increased over the period 2002 to 2019. Monitoring of inflows to Waikare from Matahuru Stream indicated an improvement phosphorus since 2017. But an improvement from such high concentrations may not be enough to reverse the trend from degrading to improving. The inflows of nutrients must first drop below the rate of loss.

Taupō nui a Tia ahead of targets

Lake Taupō is achieving water quality targets ahead of schedule. Efforts to maintain the good water quality of Taupō began in the 1970s, with fencing and planting to exclude stock from waterways flowing into the lake. Communities have also invested in nutrient removal treatment systems for municipal effluent. Rules proposed in 2005 (Variation number 5 became operative 2011) to tackle diffuse discharges of nitrogen to groundwater feeding the lake included a nitrogen cap and trade scheme (section 3.10 in the *Waikato Regional Plan*).

The targets for returning the lake to a water clarity baseline, set at the 1999 to 2003 average, are now being met. The slow movement of nitrogen through deep pumice and ignimbrite poses a real challenge for the protection of water quality for the volcanic plateau. If people had waited till monitoring data revealed significant deterioration of the lake before acting, then restoration would have been a slow process. Community action to protect Taupō, before water quality deteriorated, was a key decision.

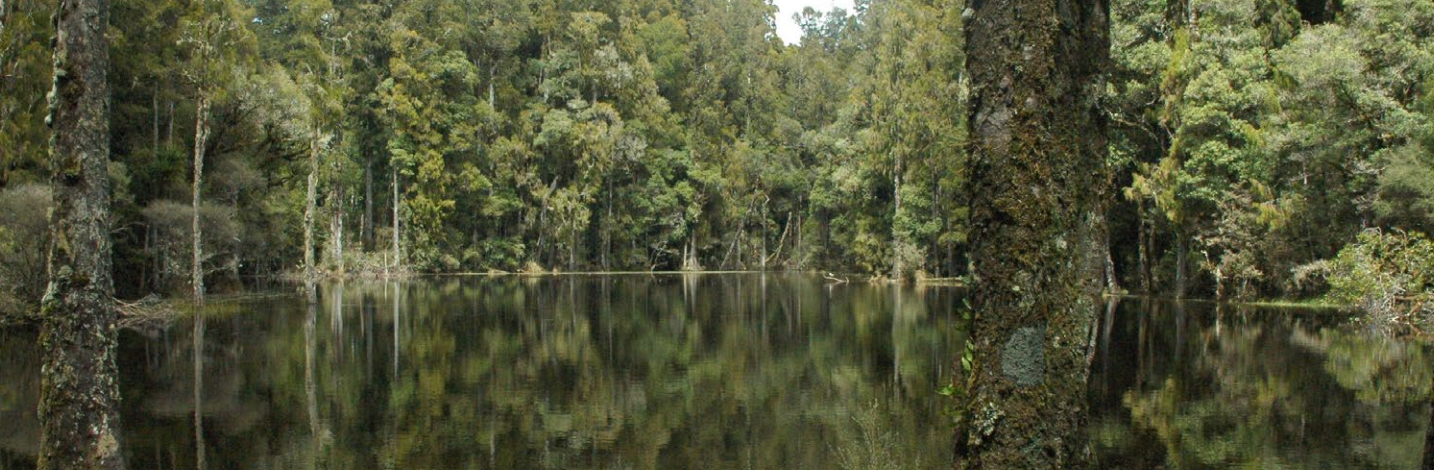
Sensitive estuaries

Estuaries are sensitive receiving environments for what happens on land. Deposited sediment and increasing nutrient inputs are key pressures. The Firth of Thames is at risk of low oxygen conditions and is already experiencing acidification associated with eutrophication from freshwater inputs.

Estuaries receive tidal flushing of ocean water twice a day, but are typically low energy environments that accumulate sediment originating from catchment erosion. Many estuarine species are sensitive to sediment, when it is held in suspension in the water column and when it is deposited on the seabed as mud. In addition, nutrients can promote nuisance growth of sea lettuce on the bed and algae floating in the water. Animals that live in or on the bed will succumb to low oxygen if loads of decomposing algae are too high. Nitrogen supply to the Firth of Thames is dominated by catchment loading, rather than sourced from offshore (Zeldis & Swaney 2018). Expansion of fish farming would add a direct loading of nutrients.

River ecosystems depend on healthy estuaries. Most of our native fish migrate from the ocean as whitebait and need to pass through estuaries, feeding and growing on the way.

Back to top



Impacts on biodiversity

Our lowland waterways are in a degraded state, reflecting 150 plus years of human impact. Many of our rivers are failing to meet bottom lines for ecosystem health.

More than 50 per cent of streams in developed catchments scored in the worst band for the MCI (Macroinvertebrate Community Index). The MCI was developed to measure response to organic pollutants. Contributing to the impact on stream invertebrates is deposited sediment, which can smother animals living on stream beds. The QMCI (Quantitative MCI) is twice as likely to be in the worst band when deposited silt covers more than 20 per cent of the stream bed, and more than half of all monitoring sites exceeded 20 per cent deposited silt. In terms of trends, the period of record revealed little improvement in invertebrate indices. Fencing and planting, plus reductions in ammonia and phosphorus, have not translated to improved MCI scores.

Biodiversity loss is more pronounced in lowland streams draining developed catchments. The types of invertebrates that are most dependent on abundant oxygen are given high taxa scores for calculating the MCI. When organic loading is raised and reaeration is inadequate, these high scoring taxa are the first to be lost from the stream. Low gradient streams, where low water velocities limit oxygen reaeration, are most sensitive to organic loading.

Native fish, although more tolerant of reduced water quality than macroinvertebrates, are sensitive to migration barriers such as perched culverts, weirs, floodgates and dams. Most native fish migrate between streams and oceans as whitebait or spawning adults. Consequently, parts of the region with good ecosystem health include steep, forested catchments with high connectivity to the sea. For example, Coromandel streams have diverse freshwater fish and invertebrate communities.

Access for whitebait to streams further inland can be cut off by waterfalls. For much of the stream network lacking natural barriers, a single perched culvert can prevent native fish from accessing upstream habitat (Jones, 2008). Reduced connectivity is likely to be a key factor constraining fish diversity in the Waikato region. Flood protection infrastructure, such as pump stations, can prevent eels from surviving their downstream spawning migration to the ocean (Duirs, 2017). Before dams were constructed on the Waikato River, natural waterfalls limited the number of eels making it upstream, however, did not block their downstream migration.

Wetlands and forest in trouble

Before being drained, peat swamps were important habitat for many species. The native mudfish continues to hold on in wet areas, such as paddock drains in peat areas. This includes old swamp soils around Hamilton where urban development is expanding. Mudfish that survived the conversion of wetland to pasture are not surviving urban development because the intermittently flowing drains that mudfish occupy are often piped and the water table lowered. Adding to this pressure, reduced rainfall and increased evaporation are expected to shorten the time mudfish have access to open water.

When drained, peat is exposed to oxygen, allowing organic matter to decompose to carbon dioxide and other greenhouse gases. The resulting shrinkage of peat lowers the ground surface, increasing demand for drainage, especially during wet periods.

Two of our biggest remaining wetlands are Whangamarino and Kopuatai. Whangamarino receives outflows from Lake Waikare, which has now reached hypertrophic levels and continues to decline in water quality. Nutrients are also a concern for Kopuatai, including areas where the Piako River flows alongside and through the wetland (outside the raised domes).

Wetlands and forest continue to be subject to development pressure with extensive clearance of indigenous forest. The efforts of many people to retire land and plant native trees has served to counter this loss, including the clearance of 2,289 hectares of shrub and scrubland. Extensive areas of indigenous forest are now protected under covenants, such as QEII and Ngā Whenua Rāhui Kawenata.

Back to top

No reduction in bacteria

Harmful bacteria and viruses entering rivers and streams compromise the safety of drinking water sources. High bacteria levels in rivers also represent a loss of places for safe swimming.

Improving the water quality for contact recreation has been a focus for Waikato Regional Council and its predecessors for many decades. For example, prior to the construction of the Pukete wastewater treatment plant in 1975, bacteria levels in the Waikato River were many times higher. More recently, fencing off streams has reduced the length of streams that cows have access to, meaning less direct input of faeces to water. Riparian areas fenced from grazing are also more effective buffers for capturing bacteria and sediment runoff.

Despite extensive fencing and planting of streambanks by farmers and community groups, monitoring does not reveal a decrease in bacteria in our rivers over the last 30 years. This surprising result cannot be dismissed as climate driven. After accounting for changes in rainfall, temperature and other factors, detailed investigation revealed an increasing trend for bacteria.

Observed bacteria levels were typically lowest in streams draining forested catchments and farmed areas of the Central Volcanic Plateau, where the pumice soils can soak up a lot of rain. When soils become compacted from high stock pressure, their ability to intercept faeces, urine and fertiliser is compromised. Intense rainfall on steep soils with low infiltration capacity is more likely to generate surface runoff, carrying sediment and attached bacteria with it.

If surface runoff was evenly distributed through the stream network, bacteria levels would be expected to reduce over time with the increasing length of streams fenced and planted. But surface runoff is not evenly spread – one study found 5 per cent of land area generated 50 per cent of sediment yield (White at al. 2009). For bacteria attached to sediment, concentrated overland flow is an effective transport pathway.

In addition to ephemeral streams, farm laneways and tracks can be critical source areas (WRC 2019). Monitoring results from 2017 showed 77 per cent of bare soil exposure on dairy farms and 37 per cent on drystock farms was on laneways and tracks. Soil compaction is necessary for animals and people to safely move about the farm. Even if the roading material is stable, faeces can accumulate on the tracks that cows use up to four times a day to reach milking sheds (Lucci et al. 2012, Monaghan & Smith 2012). Without cut-offs and soakage pits, rainfall runoff has the potential to be funnelled down farm tracks and into streams via drains or bridges.

Bacteria levels have increased where livestock density has not (NIWA, 2022). However, as milk production (per hectare and per cow) across New Zealand continues to rise (NZ Dairy Statistics), more feed is required. Intensive winter grazing on annual forage crops can help provide the additional feed, but also creates a critical source area if ephemeral streams are present.

Despite urban areas only covering 1 per cent of the Waikato region, runoff from roads and footpaths can also be a significant source of bacteria for small urban streams. The way we measure bacteria (*E. coli*) does not distinguish between contributions from urban stormwater and from farmland in the headwaters of streams flowing through Hamilton. Plenty of research indicates both are likely sources.

Cows, dogs and people are not the only source of pathogens and indicator bacteria. In the Rotopiko lake complex, large numbers of roosting birds benefiting from a predator proof fence are contributing to high bacteria counts.

Improved air quality

Improvements in air quality were achieved despite the growing population. Households have made the move away from wood burners, reducing the air pollution that can contribute to asthma and heart disease. Actions such as clean heat incentives and education campaigns are working. The World Health Organisation has recognised that reducing the concentrations of smaller particles ($PM_{2.5}$) can increase the number of healthy years of life for people, and achieving better standards in the Waikato will require further action.

Back to top

Wāhanga tekau
Part 10

Urupare
Response

People have told us they value water and are concerned about its degradation. Water quality remains one of the top environmental issues facing the Waikato region, based on 1026 people surveyed in 2022 (in the Your Environment – What Matters council survey, conducted every three years).

Other environmental concerns include climate change, waste, urban and population growth, and air quality, with similar concerns reported in national surveys by StatsNZ. Most residents (72 per cent) agree the council should ensure the environment is well looked after (Hackell, 2022).

People's perceptions are well aligned with monitoring results. It is important to recognise the limits of routine environmental monitoring for informing the management response. There are several logical steps between identifying a problem, understanding its cause and deciding on interventions to fix it.

State of the environment monitoring, scientific investigation and process modelling form the three pillars for informed resource management decisions and action by people in the Waikato region. This report provides one of those pillars, so stops short of prescribing specific actions to achieve a given target.

Recognise increasing water security issues

The Waikato has traditionally been considered water-rich, but the region is already experiencing increased water security issues. We have observed long-term trends of reducing rainfall and increasing demand. Climate change is predicted to increase drought frequency and evapotranspiration, further reducing water availability and increasing demand.

Future growth and development of the region (and its neighbours) will require improved management of water supply and demand. Actions by urban and rural users to improve water use efficiency will need to be significantly ramped up. Investigations of alternative water supply options are urgently needed. At the same time, the fundamental requirement of Te Mana o te Wai needs to be recognised and we need better understanding of how we build resilience of our natural ecosystems to water stress, while supporting human uses of water.

Better control of faecal bacteria from critical source areas through farm plans

The lack of improvement in faecal bacteria levels to date indicates that more work is needed to control potential sources. To date, action on farms has focused on stock exclusion from waterways and improved farm dairy effluent management. These should continue to be primary mitigation actions in farm plans, but we recommend extending actions to include better management of other critical source areas, such as tracks, raceways and intensive grazing of crops.

Faecal bacteria levels breach national bottom lines (NPS-FM 2020) for many streams, especially in the Waikato, Waipā and Hauraki freshwater management units where a substantial reduction in faecal bacteria is required. Extensive riparian fencing and planting has not translated to a reduction in *E. coli* concentrations in monitored streams to date. Much of the faecal discharge may be bypassing fenced buffers, negating the reduced inputs achieved from stock exclusion.

In winter, critical source areas can include intensive grazing of forage crops in areas that generate runoff. National environmental standards for intensive winter grazing came into force in November 2022.

Runoff from sections of farm tracks and laneways that drain directly into streams could also be a significant source of bacteria. Laneways and tracks represented 77 per cent of bare soil exposure on dairy farms and 37 per cent on drystock farms, according to a 2017 survey. Compacted laneways can generate runoff from less rainfall than grass paddocks, so are expected to contribute to bacterial loading more frequently than paddocks during summer.

Despite urban areas only covering 1 per cent of the Waikato region, runoff from roads and footpaths can also be a significant source of bacteria (for example from dog poo) for small urban streams. Unlike critical source areas in rural areas, stormwater discharges are normally regulated through regional plan rules.

There is a moderate level of confidence that better control of critical source areas will better control bacteria discharges, but may well be insufficient to achieve target attribute bands for *E. coli*. Streams with low levels of bacteria include those in forest areas, such as the Coromandel, and pasture streams draining pumice soils, like those flowing to Taupō. Modern farming practices can achieve low bacteria runoff in catchments with free draining pumice soils. This raises the question of how much improvement is possible on heavier soils, without addressing soil compaction. Further investigation is warranted.

Back to top

Controls on diffuse nitrogen sources, particularly for streams draining to the Firth of Thames and shallow lakes

Overall, nitrogen concentrations have increased over the last 30 years and are now high in many aquifers, streams and lakes across the Waikato region. Exceptions to this include most streams draining to Lake Taupō, where a nitrogen cap and trade system was introduced 20 years ago.

Outside the Taupō catchment, areas of pine forest near Tokoroa were cleared for dairy pasture. Nitrogen concentrations have increased in streams draining these areas, including Whakauru Stream, and this is despite extensive fencing and planting of stream margins. Near Pukekohe, nitrogen concentrations remain high in streams and aquifers draining market gardening areas.

Land management decisions for headwaters have consequences for marine life. For nutrient sensitive receiving environments like the Firth of Thames, management of diffuse nitrogen sources is important to limit algae blooms and prevent low oxygen.

The water quality of Lake Waikare has deteriorated from bad to worse in recent years. If good land management practices do not result in less nutrient inflows than nutrient outflows, farm plans may not achieve improvements in lake water quality. Other methods, such as land use change, may be required.

Recent research demonstrates nitrogen loads from shallow groundwater pathways respond within a few years to land management. Exceptions include pumice areas, like the Taupō catchment, where much of the nitrogen load can take decades to reach the stream.

A lot of research and investigation is required to confidently predict how much change in land management is required to achieve a given target in a receiving lake or estuary. Unfortunately for many lakes, we are confident the current load is too high, given water quality degradation has already proceeded to the point of harmful algae blooms or fish kills. In the case of lakes falling below the national bottom line, the NPS-FM gives communities discretion over when water quality bottom lines will be achieved.

Back to top

Better protection of soils from erosion

Sediment continues to be a problem for streams and estuaries in the Waikato region, where it smothers the habitat of small animals that live on the bed and reduces water clarity impacting multiple values.

Sediment levels in streams have not increased significantly, but we are yet to see the significant gains expected from efforts to fence and plant erodible soils and stream banks. This may be influenced by the mass of sediment already stored in streambanks and within river systems, representing a 'lag effect' between substantial catchment works to reduce erosion and the measurement of suspended sediment in rivers.

There is some evidence that sediment levels have improved more than bacteria, but the same recommendations apply for both contaminants. The main point of difference is that critical source areas for sediment might not receive faecal waste.

Forestry operations also contribute to sediment loads. Council monitoring will not reveal the consequences of easing sediment controls through the National Environmental Standards for Plantation Forestry (2017) until after most forests have been harvested. Predictions for more intense rainfall events will increase the importance of protecting erodible landscapes.

Increasing earthworks to meet housing shortfalls under the National Policy Statement for Urban Development (2020) also risks countering the benefits of soil conservation to date in rural areas. Likewise, erosion after the clearance of indigenous forest and scrub will counter the gains from regrowth and planting elsewhere.

Catchments draining to the west coast exhibited more erosion than other parts of the region, reflecting the lower capacity of this land to support development. The west coast freshwater management unit also has the lowest proportion of streams effectively fenced from livestock. Extensive areas of the Whāingaroa Harbour catchment have already been fenced and planted, and we recommend other harbour catchments be prioritised for erosion control.

Soil conservation practices are long established, and we can have confidence in what control methods work at the source. Where we have less confidence is in how much control is required to achieve a given suspended sediment or water clarity target in receiving environments. For example, there is likely much reworking of old sediment deposits in the Firth of Thames by waves and tides, topped up by recent erosion from the catchment.

Back to top

Better pathways to and from the sea for migratory fish

For stream networks without natural barriers, a single perched culvert can prevent native fish from accessing habitat upstream. For this reason, fish communities are often more constrained by access than by water quality. Beyond rules to ensure new structures provide native fish passage, we recommend the council identifies existing structures that are potential barriers and prioritise these for remediation.

The importance of fish passage is already recognised in the *Waikato Regional Plan* (Objective 4.2.2), national environmental standards (Subpart 3) and the NPS-FM (Section 3.26). It is recommended that addressing migration barriers goes beyond regulating new structures to prioritising remediation of existing structures. Such prioritisation could also help inform decisions on operation, maintenance and cost (for example, structure replacement versus a mussel spat rope). An action plan for fish passage should enable prioritisation of existing structures that prevent access to more important habitat (see MfE 2022). These action plans should be supported by the council and communities through regulatory and non-regulatory methods. The Pathways to the Sea project has already started prioritising pump stations owned and operated by the council and has investigated a range of mitigation options, including development of 'fish friendly' pump designs to enable tuna (eel) spawning migration.

Development of tools to enable identification and evaluation of existing and proposed instream structures would help answer questions like "how much habitat could be affected by a barrier at a given location?". This then limits the number of structures where more complex factors are considered, such as pest fish exclusion.

We have a high degree of confidence that remediation of existing high priority structures will generate significant biodiversity gains for Waikato streams.

Back to top

Action to meet new $PM_{2.5}$ air quality standards

Air quality is improving in most towns of the Waikato region. Actions such as clean heat incentives and education campaigns already implemented in Tokoroa are working.

The recommendation is to continue these campaigns in Tokoroa and extend them to other airsheds where proposed $PM_{2.5}$ guidelines may not be met.

Special consideration will be needed for the South Waikato and Waitomo districts, where social deprivation has significantly increased. Converting to clean heat sources and changing behaviours will benefit the health of vulnerable people in these areas.

Population growth, particularly in Hamilton city and Waikato district, is expected to add to worsening air quality from increased traffic emissions along key traffic routes. This could be mitigated by shifting to lower emission transport such as cycling and electric vehicles. Air pollution near sensitive areas, such as schools, could be mitigated by limiting vehicular flow and establishing vegetated buffers.

Gaps in environmental monitoring

State of the environment monitoring of terrestrial ecology, biosecurity, geothermal, coastal and marine biodiversity is limited. To date, monitoring has focused more on freshwater quality and quantity, with the longest datasets reflecting historic responsibilities (see Part 4).

Decades of forest damage from goat browsing are not revealed by the measures we use now. Measuring the spatial extent of wetlands from satellite imagery will only reveal change if a stand of vegetation is lost entirely.

The recommendation is to extend our routine monitoring of wetlands and forests beyond land cover, to also look at the health of these ecosystems. And monitoring the impact of pests is important in understanding ecosystem health.

In coastal areas, the extension of water quality and habitat monitoring would help us understand the consequences of how we manage the land from mountains to sea.

Rapid expansion of geothermal development as a renewable energy source, is not matched by council investment in monitoring of the resource.

Back to top

He anga whakamua
Looking forward

The way we have historically used and currently use our land and resources impacts all aspects of our natural environment, from shifts in vegetation patterns to changes in soil quality and stability, changes in water quality and quantity, and shifts in the abundance and distribution patterns of native and introduced species. We have fundamentally altered the Waikato landscape with our activities and these changes have caused cascading changes to our natural environment from mountains to sea.

Growing awareness of the environmental effects of water and land use has enabled communities to change and adapt. The state of the environment would have been far worse if not for the dedication of people to better protection of land and water. We have further to go.

Waikato Regional Council is challenged to address environmental degradation. Looking forward, community expectations for environmental improvement come from:

- *Te Ture Whaimana o te Awa o Waikato - the Vision and Strategy for the Waikato River* outlines a future where a healthy Waikato River sustains abundant life and prosperous communities (vision and strategy documents are in development for other catchments)
- national policy statements and national environmental standards, including freshwater management, biodiversity and coastal that require better environmental standards
- environmental law reform, including proposed changes to the Resource Management Act
- iwi and co-management of Te Mana o te Wai.

Wai (water), in all its forms, is considered a taonga. The mauri of wai is vital to the wellbeing of people. Wai is not considered a commodity within te ao Māori but is essential to the life of people, plants and animals. Wai is also important to cultural ceremonies and spiritual rituals. Co-governance arrangements in the Waikato bring to the fore the significance of iwi and hapū perspectives and relationships to wai. This can shift the focus from wai as a resource for the benefit of people to understanding te mana o te wai, the inherent right of water.

State of environment monitoring is backward looking, measuring what has happened to date based on attributes we already measure. The feedback that monitoring provides to policy decisions is important, and so are the forward-looking predictions of scenario models.

A growing population locally and globally will increase the demand on water and land (WISE modelling). Climate change will push some communities and ecosystems to the limit. Land use practices that may have been acceptable 30 years ago when the climate was cooler and the population smaller, may not suffice to hold the line.

Waikato Regional Council has established six strategic priorities that collectively help build a resilient Waikato. These priorities – water, biodiversity and biosecurity, transition to a low emission economy, coastal and marine, sustainable development and infrastructure, and community connections, all traverse the domains of air, land and water. How well we manage air, land and water will be reflected in environmental outcomes. Looking forward, our success in tackling environmental degradation in the Waikato region will depend on the way we work.

The mighty Waikato: caring for our place, empowering our people.

> *The state of the environment would have been far worse if not for the dedication of people to better protection of land and water. We have further to go..*

Back to top

Wāhanga tekau mā tahi
Part 11

He kōrero anō
Further reading

These technical reports are the basis of the Waikato State of Environment Report. Electronic copies can be accessed here: www.waikatoregion.govt.nz/services/publications/

For the latest monitoring information, go to waikatoregion.govt.nz/environment/envirohub/

Mō tātou, mō te toiora | Our people, our wellbeing

Huser, B.; Killerby, P. (2022) *Waikato Progress Indicators - Tupuranga Waikato: Summary update September 2022*. Waikato Regional Council Technical Report 2021/33.

Keenan, B.; Mackay, S.; Paragahawewa, U. (2022) *The economy of the Waikato region in 2022*. Waikato Regional Council Technical Report 2022/17.

Te hau | Air

Caldwell, J. (2022) *Ambient air quality monitoring report for the Waikato Region 1998 to 2020*. Waikato Regional Council Technical Report 2021/33.

Te whenua | Land

Denyer, K.; Briggs, C. (2022) *Extent of freshwater wetlands*. Waikato Regional Council Technical Report 2022/19.

Denyer, K.; Tait, D. (2022) *Indigenous coverage of protected areas on land*. Waikato Regional Council Technical Report 2022/13.

Hill, R.; Borman, D. (2022) *Pastoral land cover and intensity changes in the Waikato Region 2001-2018*. Waikato Regional Council, Technical Report 2022/51.

Jones, H.; Borman, D. (2022) *Land cover in the Waikato region, 1996-2018*. Waikato Regional Council Technical Report 2022/18.

Norris, M.; Jones, H.; Kimberley, M.; Borman, D. (2020) *Riparian characteristics of pastoral waterways in the Waikato region, 2002-2017*. Waikato Regional Council, Technical Report 2020/12.

Norris, T.; Wyatt, J. (2022) *Soil stability in the Waikato Region, 2007-2017*. Waikato Regional Council Technical Report 2021/30.

Pronger, J.; Wyatt, J.; Glover-Clark, G. (2021) *Review of potential management interventions to reduce peat subsidence and CO2 emissions in the Waikato*. Waikato Regional Council Technical Report 2021/10.

Taylor, M. (2021) *Trends in soil quality monitoring data in the Waikato region 1995-2018.* Waikato Regional Council Technical Report 2021/02

Back to top

Te wai | **Water**

Allan, M.; Baptista, M. (2022) *State of the environment monitoring Waikato lake water quality.* Waikato Regional Council Technical Report 2021/26.

Hadfield, J. (2022) *Waikato groundwater quality State of environment*. Waikato Regional Council Technical Report 2022/23.

Hunt, S. (2022) *Sediment accumulation rates in Whāingaroa (Raglan) Harbour and the Firth of Thames, 2002 / 2003 to 2021*. Waikato Regional Council Technical Report 2022/22.

Jones, H. (2021). *Regional Estuary Monitoring Programme trend report: 2001 to 2018*. Waikato Regional Council, Technical Report 2021/05.

Kamke, J. (2021) *State of coastal water quality on the west coast of the Waikato region 1994-2021*. Waikato Regional Council, Internal Series 2021/17.

Koh, S. S.; Jenkins, B. (2022) *Trends in hydrology and water resources*. Waikato Regional Council Technical Report 2022/06.

Luketina, K. (2022) *State of the Environment Report on the Waikato Regional Geothermal Resource, 2022*. Waikato Regional Council Technical Report 2022/09.

Pingram, M.; David, B.; Squires, N.; Smith, J.; Hamer, M. (2022) *Current ecological state of wadeable streams in the Waikato region.* Waikato Regional Council Technical Report 2022/32.

Ryan, E.; Jenkins, B. (2022) *State of the environment monitoring River water quality*. Waikato Regional Council Technical Report 2022/50.

Vant, B. (2021) *Trends in river water quality in the Waikato region 1991-2020*. Waikato Regional Council, Internal Series Report 2021/16.

Vant, B. (2022) *Sources of nitrogen and phosphorus in two major catchments in the Waikato Region, 2011–20*. Waikato Regional Council Technical Report 2022/05.

Vant, B.; Hadfield, J. (2022) *Water quality of Lake Taupō and its catchment, 1973–2020*. Waikato Regional Council Technical Report 2022/04.

Woodward, S.; Elliot, S.; Davies-Colley, R.; Stott, R. (2022) *E. coli trends in Waikato streams*. NIWA for Waikato Regional Council Technical Report 2022/10.

Back to top

Rārangi pukapuka
References

Bell KM, Samarasinghe O, Riggs L, Pourzand F 2021. Empirical effects of drought and climate. Manaaki Whenua Landcare Research Contract Report: LC3930 prepared for Deep South National Science Challenge, Wellington, New Zealand.

Bryant JR, Lopez-Villalobos N, Pryce JE, Holmes CW, Johnson DL 2007. Quantifying the effect of thermal environment on production traits in three breeds of dairy cattle in New Zealand. New Zealand Journal of Agricultural Research, 50:3, 327-338, DOI: 10.1080/00288230709510301.

DairyNZ, Livestock Improvement Corporation 2021. New Zealand Dairy Statistics 2020-21. www.dairynz.co.nz/media/5794941/nz-dairy-statistics-2020-21-web.pdf

Duirs R 2017. Native fish migration through land drainage and flood control infrastructure: an assessment of effects and review of management methods. Hamilton, NZ, Bloxam Burnett & Olliver Ltd.

EnviroStrat 2020. Waikato Region Greenhouse Gas Emissions Inventory For the period July 2018 to June 2019. Prepared by Envirostrat Ltd and AECOM for Waikato Regional Council. www.waikatoregion.govt.nz/environment/climate-change/waikato-regional-greenhouse-gas-inventory/

Hackell M 2022. Your environment - what matters? Waikato Regional Council Technical report 2022/48. Hamilton, Waikato Regional Council.

Jones H 2008. Compliance with Permitted Activity Rule 4.2.9.2: Ensuring culverts provide safe passage for fish. Environment Waikato Technical report 2008/22. Hamilton, Waikato Regional Council (Environment Waikato).

McDowell R, Hedley MJ, Pletnyakov P, Rissmann C, Catto W, Patrick W 2019. Why are median phosphorus concentrations improving in New Zealand streams and rivers? Journal of the Royal Society of New Zealand, 49:2, 143-170, DOI: 10.1080/03036758.2019.1576213.

Ministry for the Environment (MFE) 2022. Fish passage action plan guidance: Supporting the implementation of fish passage regulations in the National Policy Statement for Freshwater Management 2020. Publication No. ME 1625. Wellington, Ministry for the Environment.

Ministry of Works, Health Department, DSIR 1956. Report on pollution in the Waikato River basin. Prepared by Ministry of Works in co-operation with the Health Dept. and D.S.I.R. for the Pollution Advisory Council. WRC document no 25999889.

Nixon C, Kaye-Blake B, de Morel LL, Gämperle D 2021. Economic impacts of the 2019 drought. Report prepared by the New Zealand Institute of Economic Research (NZIER) for the Ministry for Primary Industries (MPI), Wellington, New Zealand.

Parliamentary Commissioner for the Environment (PCE) 2019. Focusing Aotearoa New Zealand's environmental reporting system. Wellington, Parliamentary Commissioner for the Environment.

Pingram M, David B, Squires N, Smith J, Hamer, M 2022. Current ecological state of wadeable streams in the Waikato region. Waikato Regional Council Technical Report 2022/32. Hamilton, Waikato Regional Council.

Back to top

Porteous A, Mullan B 2013. The 2012-13 drought: an assessment and historical perspective. MPI Technical Paper No: 2012/18. Wellington, Ministry for Primary Industries.

Pourzand F, Noy I, Sağlam Y 2019. Droughts and farms’ financial performance in New Zealand: A micro farm level study. Victoria University School of Economics and Finance Working Paper 3/2019. Wellington, Victoria University of Wellington.

Rainforth HJ, Harmsworth GR 2019. Kaupapa Māori Freshwater Assessments: A summary of iwi and hapū-based tools, frameworks and methods for assessing freshwater environments. Taupō, NZ, Perception Planning Ltd .

StatsNZ 2019. Environmental perceptions. www.stats.govt.nz/infographics/environmental-perceptions [Accessed 1 August 2022]

Vant W 2010. Water quality. In: Collier KJ, Hamilton DP, Vant WN, Howard-Williams C eds. The waters of the Waikato: Ecology of New Zealand's longest river. Hamilton, Waikato Regional Council; University of Waikato.

White MJ, Storm DE, Busteed PR, Stoodley SH, Phillips SJ 2009. *Evaluating nonpoint source critical source area contributions at the Watershed Scale.* Journal of Environmental Quality 38: 1654-1663. http://doi.org/10.2134/jeq2008.0375.

Zeldis JR, Swaney DP 2018. *Balance of catchment and offshore nutrient loading and biogeochemical response in four New Zealand coastal systems: Implications for resource management.* Estuaries and Coasts 41, 2240–2259. http://doi.org/10.1007/s12237-018-0432-5.

Ngā aumihi
Acknowledgements

Decades of field and lab work by staff past and present have laid the foundations for this report. Their attention to detail and persistence in the face of challenging conditions have benefited this report, and reports yet to be written.

The authors of technical reports analysed and interpreted a lot of monitoring data, and some of their findings are summarised in this document: Justin Wyatt; Simon Woodward; Bill Vant; Matthew Taylor; Daniel Tait; Rebecca Stott; Nicole Squires; Josh Smith; Eloise Ryan; Jack Pronger; Michael Pingram; Upananda Paragahawewa; Tim Norris; Matt Norris; Sarah Mackay; Katherine Luketina; Jesse Lebe; Claire Kotze; Sung Soo Koh; Mark Kimberley; Blair Keenan; Janine Kamke; Haydon Jones; Hannah Jones; Bevan Jenkins, Beat Huser; Stephen Hunt; Reece Hill; Mark Hamer; John Hadfield; Georgie Glover-Clark; Sandy Elliot; Karen Denyer; Rob Davies-Colley; Bruno David; Neil Cox; Jonathan Caldwell; Craig Briggs; Dan Borman; Mafalda Baptista; Mat Allan.

The communications and marketing section who put this report together: Masako Kato; Jeremy Tritt; Ashlea Curran; Kiriwai Mangan; Clare Hemara.

Editor: Jackie Fitchman.

Authors of this report: Thomas Wilding; Tutahanga Douglas; Jackie Fitchman; and Mike Scarsbrook.

The following people contributed to the report through project management, SOE workshops, or preparation and review of the report: Peter Wishart; Alicia Williams; Patrick Whaley; Alice Wheatley-Wilson; Andrew Wark; Urlwyn Trebilco; Michael Townsend; Keri Topperwien; Bala Tikkisetty; Hamish Smith; Paul Smith; Naomi Simmonds; Marian Ruri; Helen Ritchie; Gareth Read; Femi Olubode; Oliver McLeod; Matthew McCallum-Clark; Tracey May; Natalie Mapp; Ruth Lourey; Gill Lawrence; Paul Kennett; Andre Hay; Melissa Hackell; Angus Gray; Natasha Grainger; Eleanor Gee; Angela Fenemor; Chris Eager; Richard Doneghue; Naomi Crawford; Bryan Clements; Ed Brown; Giles Black; Anaru Begbie; Helen Andersen; Mali Ahipene.

Back to top

Ngā kupu whakamārama
Glossary

Term	Description
Ahi kā	The ‘long-burning fires of occupation’, signifying the continuous occupation of lands that can be traced through whakapapa.
Ammonia	Colourless, pungent gas composed of nitrogen and hydrogen.
Aquifer	Layer of rock that contains water within its pore spaces.
Avian botulism	Neuromuscular illness of birds caused by a toxin that is produced by the bacterium *Clostridium botulinum*.
Eutrophication	Process by which a waterbody becomes enriched in dissolved nutrients (mainly phosphorus) that promote the growth of algal and aquatic plant life and result in the depletion of dissolved oxygen.
Hapū	Kinship group, subtribe - section of a large kinship group.
Hypertrophic	Advanced state of eutrophication caused by very high nutrient loads in the waterway.
Indicator taxa	Species whose parameters (e.g. abundance or absence) are used as proxy measures of ecosystem health.
Iwi	Extended kinship group, tribe, nation, people.
Kaitiakitanga	Guardianship, conservation or protection of the natural world based on the traditions of mātauranga and tikanga.
Karst	Landscape features formed by the dissolution of limestone bedrock, such as sharp fluted ridges, fissures, sinkholes and cave systems.
Ki uta ki tai	‘Mountains to sea’; a holistic approach to the sustainable management of water.
Macrophyte	Aquatic plants growing in or near water.
Mahinga kai	Place where wild food or other resources are harvested.
Mana whenua	Authority over lands that are traditionally associated with a tribe.
Manaakitanga	The expression of mana shown through the respect, generosity and protection towards other people and the environment.

Back to top

Term	Description
Mātauranga Māori	The intellectual capital (inherited and new knowledge, values and ethics) generated by whānau, hapū and iwi over multiple generations.
Mauri	The life-giving power which permits all living things to exist within their own realm and sphere.
Oligotrophic	Waterbody with a low nutrient load, characteristic of clean water.
Peatland	Terrestrial wetland ecosystem in which waterlogged ground promotes the accumulation of peat (partially decomposed organic matter).
Riparian zone	Lands adjacent to a river or stream.
Te taiao	The natural world, composed of the interconnected systems of land, water, climate and life.
Tikanga	Encompassing system of Māori cultural protocols and practices.
Wāhi tapu	A sacred place.

Back to top

Ngā taumata
Standard Units of Measure

Unit	Measurement
°C	Degrees Celsius
ha	Hectare
$PM_{10}/_{2.5}$	Particle matter (size measured in micrometres) found in dust and smoke
m^3/s	Metres cubed per second, measurement of volume flow rate

Ngā kupu rāpoto
Acronyms

Acronym	Description
DPSIR	Drivers, Pressure, State, Impact and Response framework
MCI	Macroinvertebrate Community Index
NPS-FM	National Policy Statement for Freshwater Management
QMCI	Quantitative Macroinvertebrate Community Index
WPI	Waikato Progress Indicators / Tupuranga Waikato

Back to top

He taiao mauriora ▲ **Healthy environment**

He hapori hihiri ▲ **Vibrant communities**

He ōhanga pakari ▲ **Strong economy**

Policy Series PS23/04
ISSN 2230-4339 (Print)
ISSN 2230-4347 (Online)
Printed September 2023 #7364

Private Bag 3038, Waikato Mail Centre,
Hamilton 3240, New Zealand
0800 800 401 waikatoregion.govt.nz