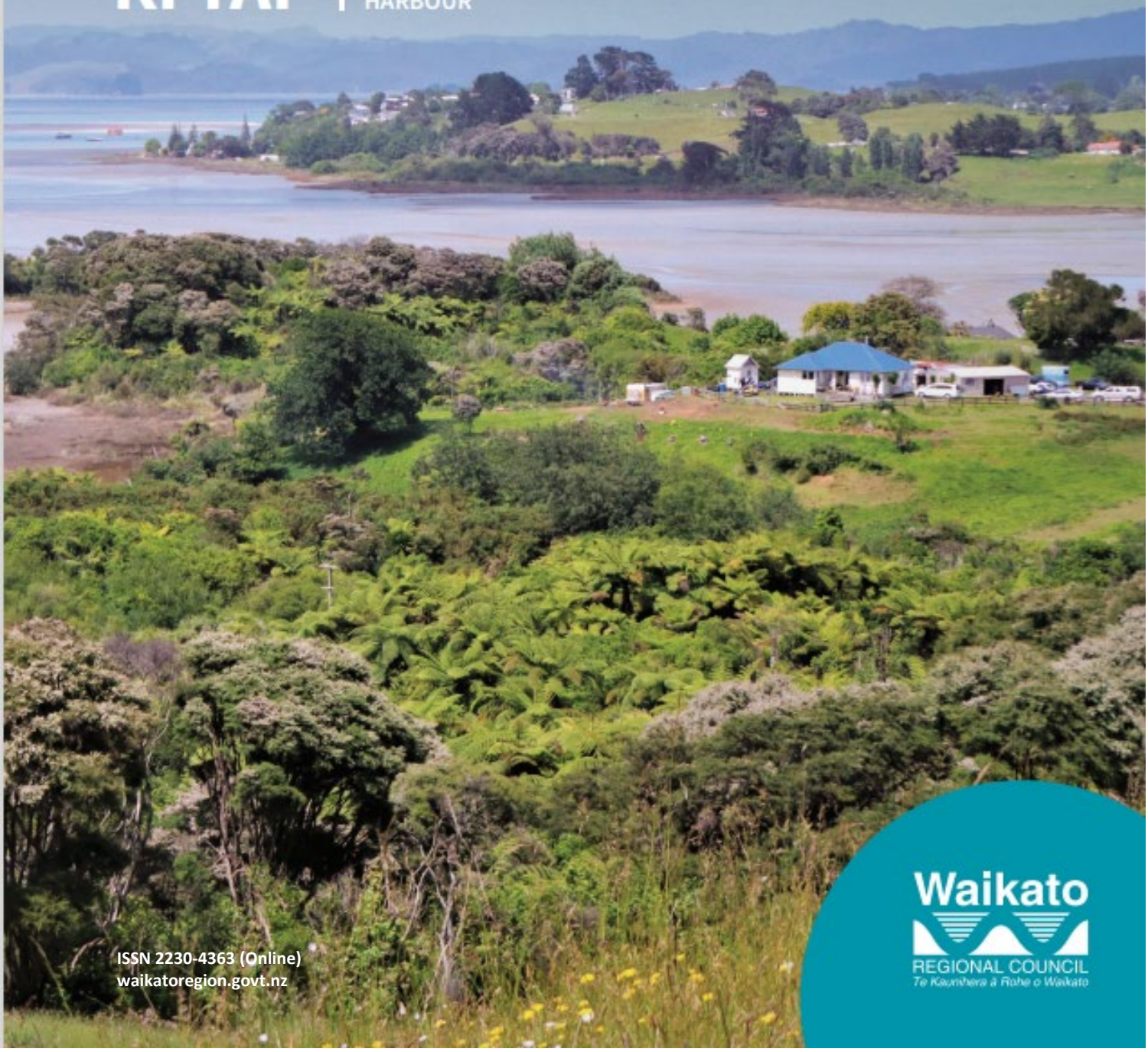
Waikato Regional Council
Technical Report 2024-06

Kāwhia
Catchment Management Plan

Supporting information

KI UTA KI TAI | HEALTHY CATCHMENT HEALTHY HARBOUR



ISSN 2230-4363 (Online)
waikatoregion.govt.nz

Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Kāwhia Catchment Management Plan: Supporting Information

Contributors

Prepared by:
Tracie Dean-Speirs, Amy Taylor, Keri Neilson, Leanne Lawrence

For:

Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
Hamilton 3240

The project team gratefully acknowledges the following people who provided technical input into the development of the Kāwhia Catchment Management Plan: Supporting Information: Dan Borman and Craig Briggs - Spatial information, Callum Bourke, Taylor Scott, Lyndon Stokes, Adrian Jepson, Matt Noble (River and Catchment Management Officers - ICM), Biodiversity and Biosecurity team members, Coastal, Freshwater and Land and Soil scientists.

Peer reviewed by:
Hilke Giles Date April 2024

Approved for release by:
Grant Blackie Date September 2024

Disclaimer

Contents

Tables

Figures

List of acronyms used in this document

CMA	Coastal Marine Area
HCMP	Harbour Catchment Management Plan
NPS-FM	National Policy Statement for Freshwater Management
NZCPS	New Zealand Coastal Policy Statement
RMA	Resource Management Act
RPS	Regional Policy Statement
SNA	Significant Natural Areas
SOE	State of the Environment
WRC	Waikato Regional Council
WRPS	Waikato Regional Policy Statement

Executive summary

This report has been compiled to inform the development of the Kāwhia Catchment Management Plan currently being prepared by Waikato Regional Council. It provides a summary of technical information held by Waikato Regional Council as well as information provided by some external sources.

Information is grouped into the following sections:

- Physical characteristics of the catchment
- Catchment land use and activities
- Erosion and sediment
- Water quality
- Biodiversity
- Biosecurity
- Hazards
- Climate change
- Prioritisation

The land catchment area of the Kāwhia harbour is approximately 48,000 hectares of land along the west coast of the North Island of New Zealand. The Kāwhia catchment includes 709 kilometres of streams and has been divided into seven sub-catchments by Waikato Regional Council for management purposes: Kāwhia, Mangaroa, Oparau, Te Kauri, Awaroa, Te Toi and Waiharakeke. Kāwhia harbour itself is a large estuary that extends over 6,765 hectares.

The catchment boundaries are formed by high steep hills. Soft sedimentary rocks like siltstone and mudstone, which are fractured, unstable and prone to erosion, make up a large percentage of the catchment. There are also many outcrops of limestone. Flat to rolling slopes in the catchment are stable and covered by alluvium.

In the past most of the catchment would have been entirely covered in indigenous vegetation with 70% of this primary forest. Species included extensive rimu-tawa forest cover that extended over the hill country, with more broadleaved species present at coastal sites, and kauri occurring in isolated stands within the Te Kauri Stream catchment. Conifer-broadleaved forest dominated at higher (montane) altitude with dense podocarp forest at low altitude alluvial sites. Extensive duneland vegetation occurred around the entrances the harbour, while freshwater wetland areas were present to a lesser extent.

The Kāwhia catchment has changed and developed over time, particularly since human settlement. Removal of native vegetation has resulted in increased area of pasture for farming. Almost half the catchment is now pasture (49%), 45% is in some form of native woody vegetation, and the small amount of remaining land cover is split between forestry (3%) and wetland and sand covered areas (3%). The conversion to pasture and high percentage of steep to moderately steep land (85%) that is prone to erosion has led to high sediment loads within waterways and the harbour.

Overall, water quality in rivers and streams in the Kāwhia catchment is of reasonable quality in comparison to other parts of the Waikato region that have more intensive land use. In terms of total nitrogen and phosphorus water quality can be described as relatively good and in terms of water clarity as moderate. *E. coli* levels, indicating potential health risk to people swimming in rivers and streams, are of concern for the Kāwhia catchment. Summary data for the 2016-2020 period indicates

that the Oparau River, the only river that is routinely monitored, is not considered to be safe for contact recreation (swimming). Run-off and leaching from pastoral land use is the main source of contaminants to the harbour, which is exacerbated during wet conditions.

The ecological health of the four river and stream sites routinely monitored has been assessed as excellent to good based on their macroinvertebrate community index.

Water quality in Kāwhia Harbour is generally good. The harbour is well oxygenated, has good water clarity, low phytoplankton levels, and low total phosphorus. Occasional elevations in total nitrogen occur during winter and are likely caused by catchment run-off during the wetter seasons. More than 75% of dissolved reactive phosphorus measurements since 2019 have exceeded guideline values for all but one site in the harbour, mostly during winter months. Water quality in Kāwhia Harbour is suitable for contact recreation most of the time. The current suitability of harbour water quality state for shellfish gathering is unknown due to a lack of recent monitoring data. In general, water quality in Kāwhia Harbour reflects water quality of the rivers and streams in the catchment. There are declines during winter and wet weather events when rainfall in the catchment increases contaminant loads in rivers and streams that reach the receiving harbour waters.

Despite its extent of modification, the Kāwhia catchment retains some extensive and important areas of indigenous vegetation, and numerous smaller areas that are critical for a number of rare and threatened species.

As in the rest of New Zealand, wetlands have been reduced and lost from the Kāwhia catchment as a result of drainage and historical land use changes. Although substantially reduced already, there is evidence that wetland loss has also continued in recent times, despite policies and rules that were intended to protect them.

Kāwhia harbour supports very extensive and ecologically important seagrass (*Zostera* sp.) beds that extend over 842 hectares in varying density. For example, these areas far exceed the total area of seagrass in all of the Coromandel Peninsula harbours combined.

Kāwhia Harbour is a site of importance to shorebirds and seabirds. It is considered to be nationally important as a wintering site for indigenous and international shorebirds, including pied oystercatchers, black stilts, banded dotterels and pied stilts.

Waikato Regional Council undertakes a range of monitoring, surveillance, enforcement and direct pest control work in conjunction with other stakeholders in the catchment. There has been a focus possum and goat control. Swan and Canada geese populations have been identified as being of particular concern for the community in West Coast harbours, with concern over the impact of trampling and feeding on sea grass, deposition of faecal material and impact on other birds.

Pest plants of concern in the most recent survey of the Kāwhia harbour catchment were Spartina, boneseed, evergreen buckthorn, prickly pear cactus, simla, wild ginger, climbing asparagus and bamboo grass. Control programmes for targeted pest plants continue and the Department of Conservation has undertaken Spartina eradication recently.

The Waikato region in general is prone to natural hazards such as coastal erosion, sand drift, wind erosion, coastal flooding, changes in sea-level, tsunami, storms, and cyclones. As a result of climate change the West Coast harbour catchments will likely be subject to more of the high intensity rainfall and storm events that trigger short-term erosion and subsequently increase sedimentation in rivers, streams, and the coastal environment.

Prioritisation exercises undertaken by Waikato Regional Council in 2018 and 2021 have identified Te Kauri and Awaroa sub-catchments as being high priority for management of soil conservation and erosion.

The data and information collated in this report has been used alongside input from iwi, landowners, community, and stakeholders to develop goals and actions for the Kāwhia Catchment Management Plan.

1 Physical characteristics of the Kāwhia catchment

1.1 General description

The Kāwhia Harbour catchment covers approximately 48,000 hectares of land along the west coast of the North Island of New Zealand (Figure 1). The Kāwhia catchment includes 709 kilometres of streams[1] and has been split into seven sub-catchments for management purposes by Waikato Regional Council: Kāwhia, Mangaroa, Oparau, Te Kauri, Awaroa, Te Toi, and Waiharakeke (Figure 2).

Figure 1. NZ Topographic map of the Kāwhia catchment.

[1] Based on REC2 watercourses

Kāwhia township is the main residential area within the wider catchment and has a small permanent population of approximately 348 people, which has declined over recent years. The local population expands significantly to around 3000 people during summer months to accommodate seasonal visitors, holiday makers, and whanau that reside elsewhere but return regularly. The wider Kāwhia catchment has a population of c. 1848 people (Singleton 2018).

The Kāwhia catchment sits within the Waikato Regional Council West Coast Zone, which covers an area of 425,835 hectares, or approximately 17 per cent of the Waikato region, stretching from Port Waikato in the north, to Mokau River in the south, and as far inland as Benneydale. District councils with responsibilities in the Kāwhia catchment are Waikato District Council (WDC), Ōtorohanga Council (ODC) and Waitomo District Council (WDC).

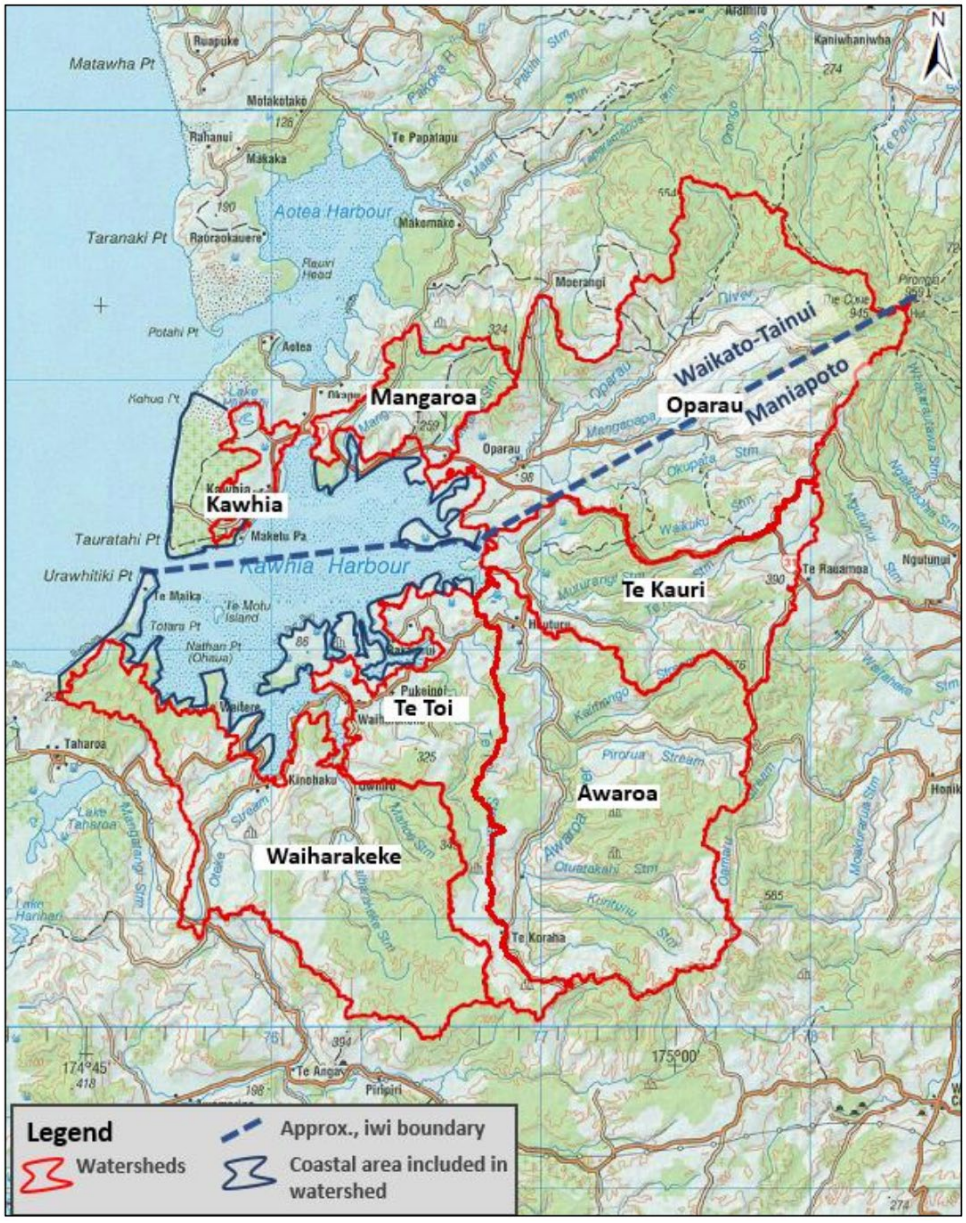


Figure 2. Kāwhia sub-catchments and key waterways within the Catchment. Source: Singleton (2018).

The Kāwhia catchment boundaries are formed by high steep hills which have been uplifted by folding and faulting and extend the whole length of the West Coast Zone. The catchment ranges in elevation from sea level to about 959 m above sea level on the southern slopes of Mount Pirongia in the Oparau River sub-catchment. The catchment is steep with 85% of the land being moderately steep or steeper, and prone to erosion.

Seventy-two per cent of the catchment is siltstone and sandstone with 19% volcanic basalt and small areas of clay, limestone and sand (Singleton, 2018). The sedimentary rocks are often fractured, unstable and prone to erosion. Harder sandstone and limestone also occur and can be seen exposed as bluffs and cliff faces.

Over time, several metres of volcanic ash have fallen in a sequence of volcanic events. Most of the ash has since eroded from the steeper slopes exposing the underlying subsoil or rock. Today, material eroded from hill slopes and stream banks is deposited onto alluvial flats, and into the harbours (Singleton 2018). Soils on volcanic ash on flat to rolling slopes are highly productive and used for dairying, cropping and dry stock. They form relatively stable surfaces and nutrient loss, rather than slope erosion, is the key issue. On steeper slopes where this ash cover has been removed by erosion the underlying clay subsoil or rock is nearer the surface and runoff is more likely. The cumulative effects of naturally unstable soils and extensive farming results in high sediment loads within some of the waterways in the catchment.

Rainfall within the catchment varies between the different geographical areas, with areas closest to the coast receiving c. 1600 mm rainfall per year, while the top third of the catchment receives 2300-2500 mm of rainfall annually (Singleton 2018).

Kāwhia Harbour is the largest of three harbours within the West Coast Zone, covering an area of c. 6,765 hectares (Waitomo District Council, 2009). The harbour has a complex shoreline and extensive intertidal flats that are the result of drowned river valleys that formed during low sea levels and filled as water levels rose. The harbour entrance has a sandbar and a high coastal dune barrier. Kāwhia Harbour is an area with considerable cultural, ecological, and historical values, and has a long history of settlement.

A range of factors such as isolation, low intensity land use and low population densities have helped to maintain the harbour and its catchment in a relatively healthy condition (Waitomo District Council, 2009). The coastal waters and harbour margins have been formally identified as areas with Outstanding Natural Character. The harbour itself is recognised as an Area of Significant Conservation Value (ASCV) in the Waikato Regional Policy Statement (WRPS).

1.2 Land cover

The current land cover within the Kāwhia Harbour Catchment is shown in Figure 3 and is summarised in a graph in Figure 4. Almost half of the Kāwhia catchment is in pasture (49%) and the rest is in native woody cover (45%) with some exotic forestry (3%), wetland and sand. Around 38% of the catchment is covered in indigenous forest which is generally found near the outskirts of the catchment boundary, but patches can be found throughout the catchment. The mid to low lying areas of the catchment are generally dominated by high producing exotic grassland with some manuka/kanuka and exotic forestry scattered amongst these areas. There is very minimal built-up area within the catchment.

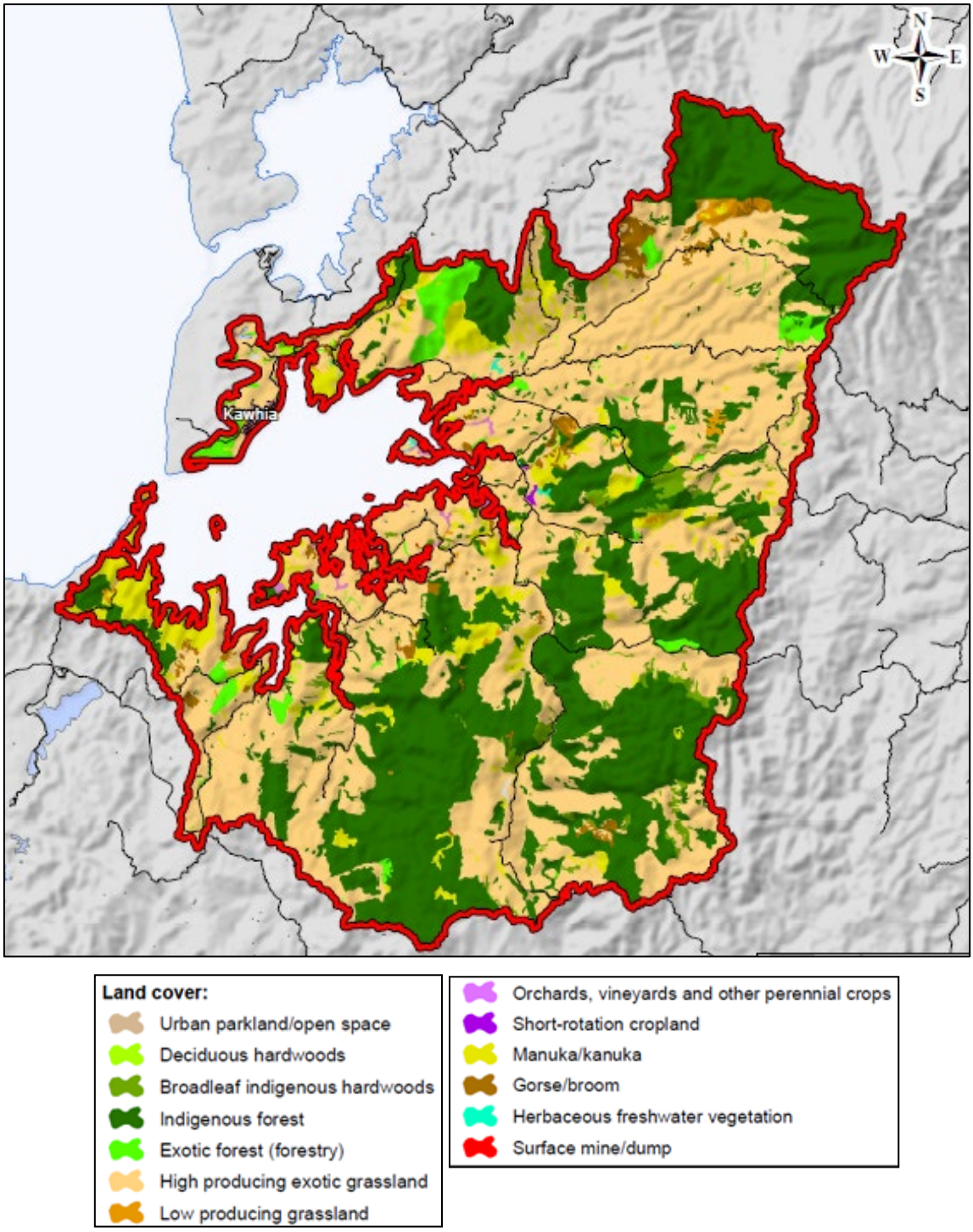


Figure 3. Overlay of land cover within the Kāwhia catchment

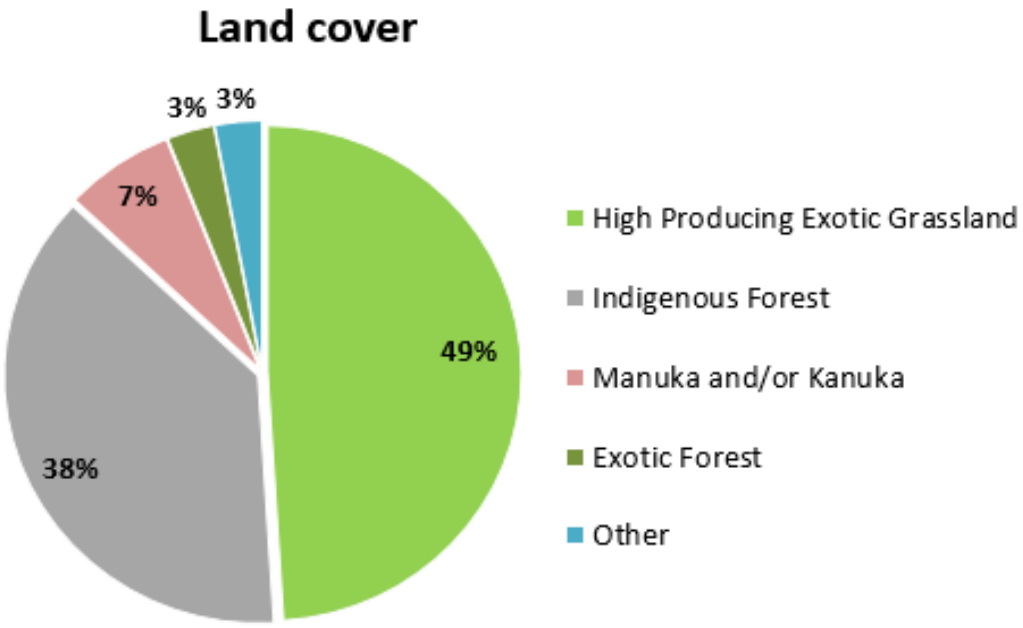


Figure 4. Land cover in the Kāwhia Harbour catchment (Singleton, 2018).

1.3 Erosion risk

1.3.1 Soil erosion

Erosion is the natural process of wearing away rocks, geologic, and soil material via water, wind, or ice. Erosion thus transports materials after mechanical weathering has broken rock and geologic materials down into smaller, moveable pieces. New Zealand is geologically young and active and, as a result, the natural level of erosion is high by international standards. Erosion is a natural phenomenon which results in soil losses and can lead to water quality degradation. Changes to the vegetative cover of the land brought about by activities such as farming, introduction of pests, burning, forestry, road construction and urban development reduce protection against erosive forces and lead to accelerated erosion.

The susceptibility of soils to erosion is the result of a complex set of interactions between soil type, climate, vegetative cover, terrain characteristics (slope and aspect) and land management practices. Steeper land that has been cleared from native forest is generally more susceptible to accelerated erosion than other areas. Climatic or weather conditions combined with human activity can accelerate soil erosion. Soil is a finite resource. Once erosion has occurred, the productivity of the soil rarely returns to its former level.

Data from the New Zealand Land Resource Inventory indicates that 85% of the Kāwhia catchment (Figure 5) is moderately steep or steeper. These areas, with slopes greater than 21 degrees, have slight to moderate risk of sheet and slip erosion, with the steepest areas also having gully erosion risks. The slope of the land in the Kāwhia catchment is a major constraint on land use development because of the risk of erosion and soil loss. In general, moderately steep and steeper land is rarely cultivated as cultivation is impractical and carries a high level of erosion risk. Cultivation on strongly rolling areas is also limited resulting in longer pasture rotations. Forestry is generally possible with tracked machinery on slopes up to a maximum of 26 degrees.

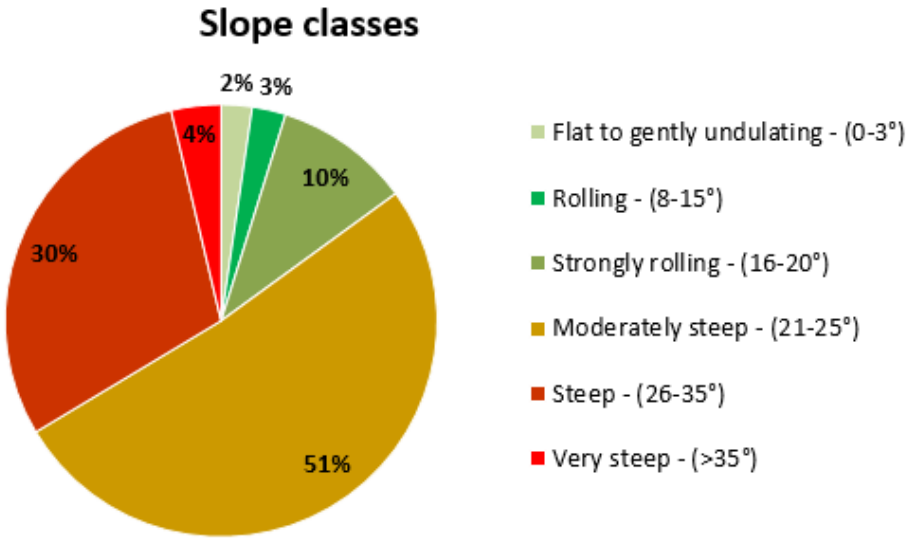


Figure 5. Slope classes in the Kāwhia Harbour catchment derived from New Zealand Land Resource Inventory (Singleton, 2018).

Summary statistics regarding erosion risks within the Kāwhia catchment (Table 1) were documented in the unpublished report to inform the West Coast Zone Plan (Waikato Regional Council, 2016). Large areas of the hill country within the catchment have high erosion risk and sediment yield with an estimated loss of 204 tonnes/km^2/yr. These areas have high rainfall (1,600 to over 2,500 mm per year) in the headwaters and are prone to shallow slip and sheet erosion, particularly where heavy livestock are grazed on steep land (Singleton, 2018).

Waikato Regional Council's Waikato Regional Prioritisation Project (discussed further in section 9) has been developed to provide a relative and objective overview of the biophysical information in each sub catchment (Norris *et al.* 2021). The outputs are intended to guide where on-ground restoration and conservation efforts are best focussed to achieve catchment water quality targets. Initial identification of potential priority catchments for erosion and sedimentation management actions was based on the GIS based framework outlined in Hill *et al*. (2015) and Hill and Borman (2016).

Table 1. Area of land susceptible to erosion risks within the Kāwhia catchment and compared to the other two West Coast harbour catchments (Waikato Regional Council, 2016).

	Whāingaroa	Kāwhia	Aotea
Landslide risk for delivery to water (ha)	988	1625	351
Total area of highly erodible land (ha)	4090	2606	451
% of catchment that is highly erodible land	8	5	3
Estimated sediment yield (tonnes/km^2/yr)	233	204	197
Estimated properties with highly erodible land	176	128	29

1.3.2 River and stream bank erosion

River and stream banks are subject to the erosive force of water, which can be exacerbated by land use activities that damage or disturb the banks and beds of rivers and streams. River and stream bank erosion can damage and remove habitat and release sediment into the water.

In the Kāwhia catchment there are still many watercourses with little or no erosion protection in place or where stock can access, accelerating stream bank erosion. The WRC Riparian Characteristics survey (Norris et al. 2020), reported that West Coast zone is the area of the region with the lowest proportion of riparian margins with effective fencing (28% of bank length), stock exclusion (16%) and the second highest incidence of stream bank erosion (23%). Climate change is expected to result in more frequent extreme rainfall events, further exacerbating bank erosion and sedimentation problems.

1.3.3 Coastal erosion

Coastal erosion is a natural process that is part of natural beach behaviour. When viewed over a long period, such as a hundred years, most shorelines are simply shifting backwards and forwards. Most shorelines naturally vary between periods of sand erosion[2] and accretion[3]. Short-term erosion can also be caused by storms. The area usually recovers; however, and a full erosion and accretion cycle can take several decades. Climate change is expected to result in more frequent extreme weather events, further exacerbating coastal erosion problems.

It is likely that significant shoreline fluctuations in the Kāwhia area occur over periods of decades in response to sediment bypassing of the harbour entrance and offshore changes on the ebb tide delta (Tonkin and Taylor, 2008). Tonkin and Taylor Ltd (2008) report that the main sandy beaches occur in the lower area of the harbour, particularly the northern side of the entrance channel, the shoreline adjacent to Maketu Marae, and the beach backed by a single dune at Te Maika. In other areas of the harbour, beaches tend to be more limited veneers of sand over firmer materials. The shoreline along the northern side of the entrance has experienced significant periods of erosion in the past, including the early 1990's when the shoreline was littered with pine trees undermined by the erosion. However, there is no development in the area likely to be threatened by such erosion. There have been historical accounts of the shoreline adjacent to Maketu Marae experiencing periods of erosion, threatening Te Ruruhi, the oldest standing building on the marae. In order to protect the marae, a seawall was built in 1971 and reinforced in 2004 (Tonkin and Taylor Ltd, 2008).

An unpublished report by Dahm (2021) describes an overall pattern of shoreline change at Te Maika since the earliest survey in 1902 as having with a trend for erosion at the northern end of the beach and accretion at the very southern end. Over time, various ad hoc sea walls have been built in some areas of the shoreline fronting the baches in an attempt to constrain erosion. Data suggested that erosion at the site is associated with both decadal shoreline fluctuation (temporary erosion) and a longer-term trend for permanent erosion since the 1970s. It is concluded that it is unlikely that continued occupation of the District Council reserve by the existing baches will be practicable and sustainable (Dahm, 2021).

The other areas of the harbour where there has been erosion in the past or where there is a risk of coastal erosion/inundation include:

a. the foreshore of Kāwhia township.
b. the road to Kāwhia where it is close to the shoreline in places.

[2] gradual washing away of land along the shoreline
[3] gradual increase or acquisition of land washing up sand or silt from the sea

c. erosion at Te Waitere with some houses and properties threatened in the 1990s.
d. periodic inundation of low-lying areas around Kawhia Harbour including an old cemetery; and
e. serious problems with sand instability between Aotea and Kawhia harbours.

Problems related to coastal erosion typically involve infrastructure built adjacent to the coastline during times of accretion that are at risk of coastal inundation during times of erosion. It's likely that where sand extends below high tide it may be vulnerable to erosion over periods of decades to centuries.

1.4 Land suitability for production

1.4.1 The land use capability classification system

In New Zealand the land use capability (LUC) system is well established as a method to distinguish land areas according to their capacity to support long-term sustained production (Lynn et al., 2009). The LUC classification assesses five primary physical factors: rock type, soil, slope angle, erosion type and severity, and vegetation cover, which influence the long-term land use potential.

The LUC classification can be used to develop tools for land evaluation or farm planning, for example for identifying land-use configurations and/or mitigation measures that maintain or optimise profitability while minimising contaminant loss or water use.

LUC classes range from LUC Class 1 (highly versatile) to Class 8 (unsuitable for production). Land of classes 1 to 4 are versatile for a range of productive uses, including cropping, pastoral grazing or forestry. Beyond class 4, land is no longer suitable for cropping but can be used for pastoral grazing or production forestry. LUC class 8 lands are considered to be unsuitable for any type of production, but generally have important conservation and watershed protection values where indigenous vegetation has been retained.

LUC classes can be further divided into LUC subclasses that describe the main kind of physical limitation or hazard to use of the land parcel. The four limitations recognised are:

'**e**': **erodibility** (where susceptibility to erosion is the dominant limitation)

'**w**': **wetness** (where a high-water table, slow internal drainage, and/or flooding constitutes the major limitation to use)

'**s**': **soil** (where the major restriction to use is a limitation within the rooting zone. This can be due to a shallow soil profile, stoniness, rock outcrops, low soil moisture holding capacity, low fertility (where this is difficult to correct), salinity or toxicity)

'**c**': **climate** (where the climate is the major limitation to use. This can be summer drought, excessive rainfall, unseasonal or frequent frost and/or snow, and exposure to strong winds or salt spray)

1.4.2 LUC classification of the Kāwhia catchment

The ability to use land in the Kāwhia catchment for production is limited (as shown in Table 2) with 90% of the catchment assigned to LUC class 6, 7 or 8 and is largely limited by erosion or wetness. Ten percent of the catchment falls into LUC classes 3 and 4. Overall, the catchment does not have any highly versatile land (LUC classes 1 or 2).

For the Kāwhia catchment the area of pasture (49% of the catchment) equates to approximately 23,520 hectares. Of this 74%, or 17,417 hectares, is in pasture on class 6e land and 0.3% or 71 hectares

is on class 8 land, there is no (or very little) class 7 land in pasture (refer Figure 6). Vegetation clearance and agricultural intensification in areas where the land has limited capability (class 6e and above) can contribute to erosion and sedimentation issues.

Table 2. Summary of the LUC classification for the Kāwhia Harbour catchment

LUC Class	Description	Area (ha)	% Catchment
3	Moderate limitations - can be used for cultivated crops, pasture or forestry	134 (3e) 775 (3w)	2
4	Land with severe limitations to arable use. Careful management required. Usually kept in pasture for long periods	3,653 (4e)	8
6	Mostly good, fairly stable, hill country where soil erosion can be minimised by good pasture establishment and management. Suited to grazing and forestry.	35,558 (6e) 163 (6s)	75
7	This land is unsuitable for arable use and has severe limitations or hazards under perennial vegetation. Usually not suited for grazing as it requires special soil conservation practices. In some cases it may be moderately suited to forestry.	5,226 (7e) 1,071 (7s) 44 (7w)	13
8	Predominantly very steep mountain land. Land has unfavourable characteristics and severe limitations to use. Unsuitable for forestry and grazing and best restricted to catchment protection and recreation.	832 (8e) 40 (8s)	2

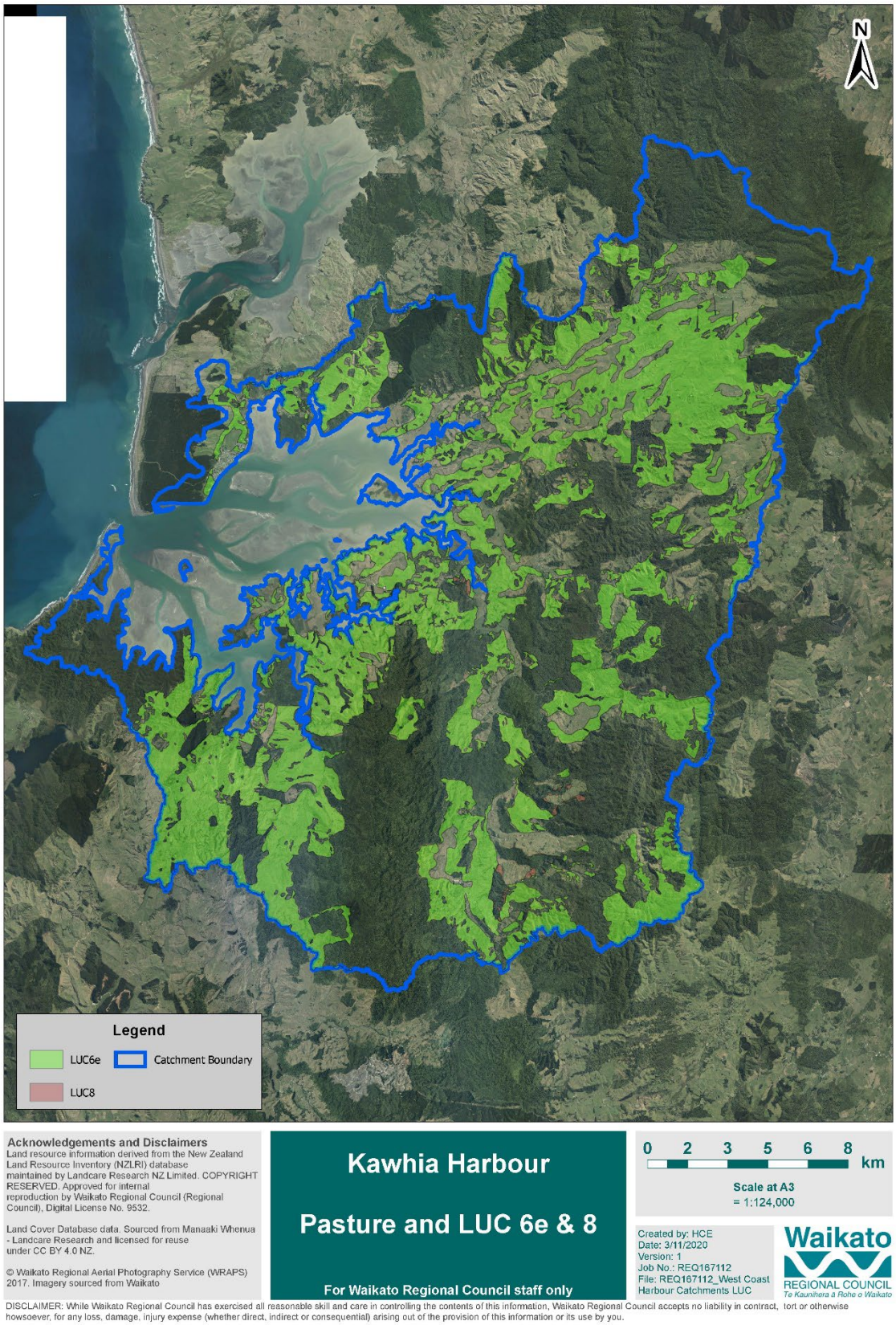


Figure 6. May of LUC 6e and 8 class land with pastoral land use within the Kāwhia Catchment

2 Catchment land use and activities

2.1 Introduction

The way we use the land and the activities we carry out on our land affect the environment. Some effects are clearly noticeable and easily ascribed to a specific land use, for example the effects of deforestation on land cover. However, other effects are less obvious, and it's the cumulative effects of the various land uses that contribute to environmental degradation.

There are three main land use categories in New Zealand: production, conservation, and urban and rural development. Figure 7 shows the different land use classes within the Kāwhia catchment. It is noted that there are some gaps in the data regarding the exact proportions of land use in the catchment. However, the predominant land use within the Kāwhia catchment is pastoral sheep and beef farming, which is estimated at 54% of the catchment, followed by native bush (23%) (Singleton, 2018).

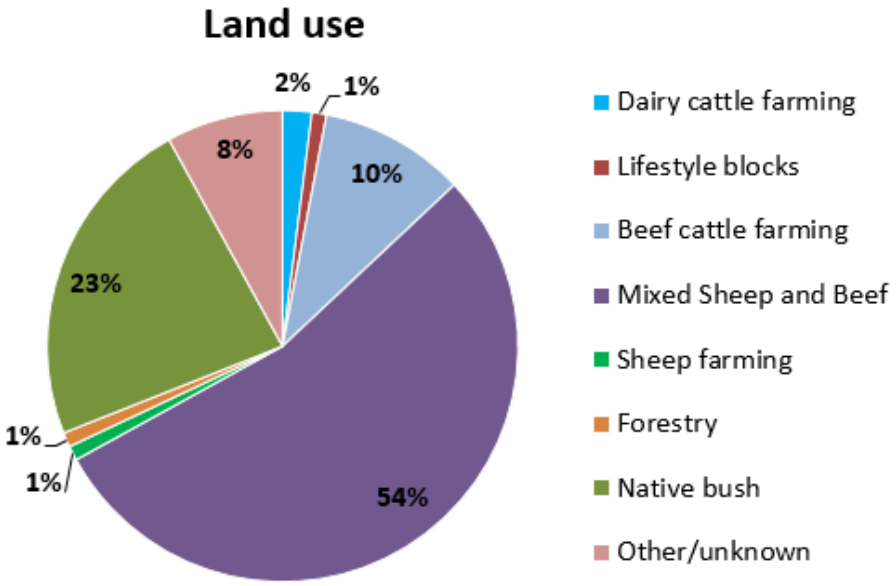


Figure 7. Land use types within the Kāwhia catchment (Singleton, 2018)

In the following sub-sections we describe the main land uses and activities in the Kāwhia catchment:

f. Urban and rural development (including coastal development, sections 2.2 and 2.3).
g. Conservation (legally protected land and conservation activities on private land, section 2.4).
h. Production (plantation forestry and farming, sections 2.5 and 2.6); and
i. Tourism (section 2.7).

2.2 Urban and rural development

Approximately 3% (1,542ha) of the Kāwhia catchment area has been developed for urban and peri-urban settlements. The direct effects of urban development are changes to land cover, often including removal of vegetation and erosion during construction. The latter typically also applies to the construction of subdivisions.

There are a total of 1222 properties within the Kāwhia catchment as of 2020[4]. Almost 65% (783) of these properties are privately owned, with around 27% (325) in freehold Māori ownership, and 9% (114) in Crown ownership (refer to Figure 8).

In New Zealand concerns have been raised about the loss of some of our most versatile land through expansion of urban development on highly productive land (Ministry for the Environment and Stats NZ, 2021). The problem is that we only have limited quantities of this land and further loss may reduce economic opportunity. Considering the small proportion of developed land in the Kāwhia catchment, coupled with decreasing population rates, it is unlikely that this is a problem.

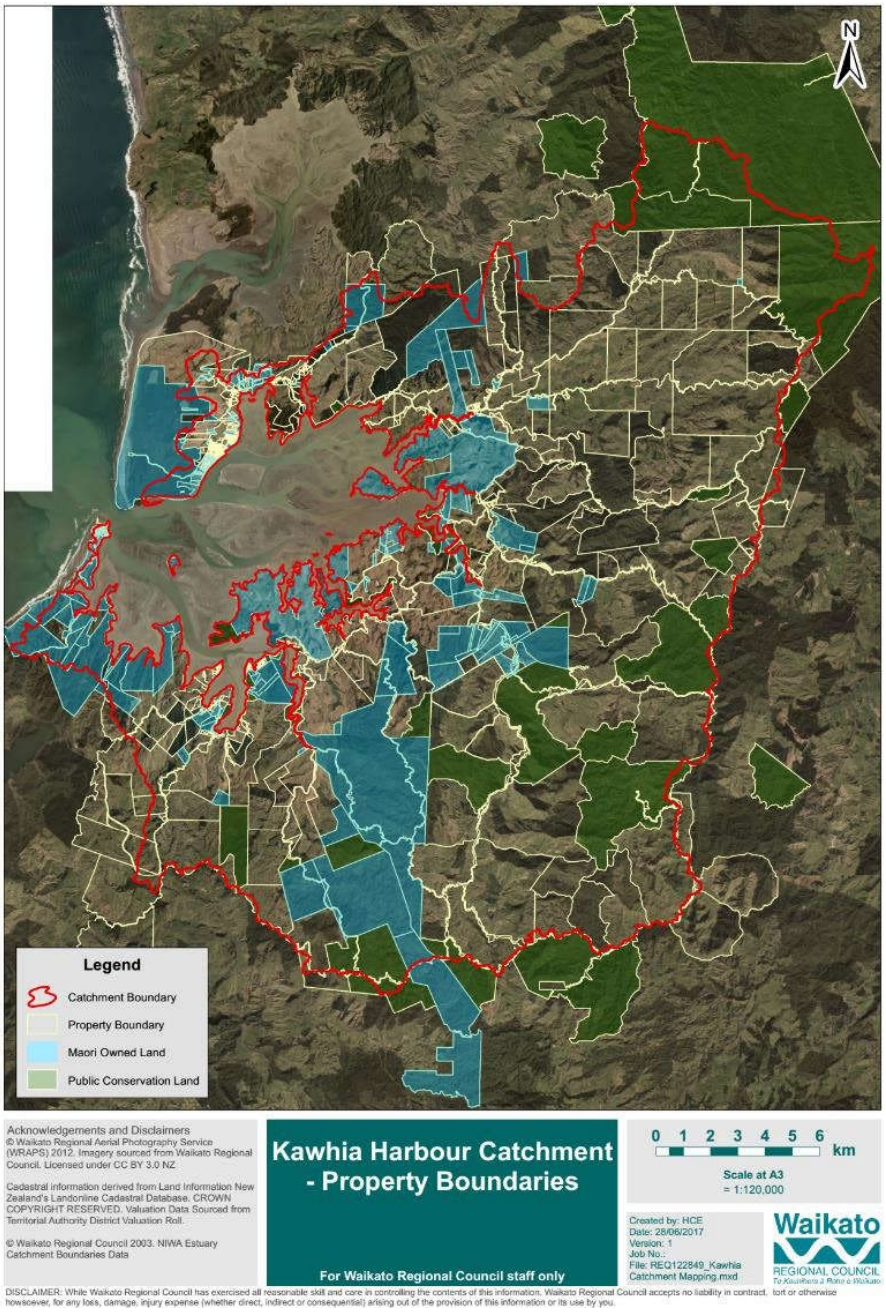


Figure 8. Property ownership within the Kāwhia Catchment

[4] Rating units by ownership type

2.3 Coastal Development

The coastline of the Kāwhia catchment is relatively undeveloped and consists of a mix of extensive open coast beaches, harbour beaches, sand spits and sea cliffs. Monitoring data on coastal dynamic trends within the catchment is somewhat limited, however, what is currently available has been summarised below.

There have been historical accounts of the shoreline adjacent to Maketu Marae experiencing periods of erosion, threatening Te Ruruhi, the oldest standing building on the marae. To protect the marae, a seawall was built in 1971 and reinforced in 2004. More information about coastal erosion is provided in section 1.3.3.

2.4 Legally protected land

Approximately 17.5% of the Kāwhia catchment area is administered by DOC as public conservation land to protect its natural, scenic and recreational values[5] with a further 6.2% of the catchment area (in private ownership) protected through QEII and Ngā Whenua Rāhui covenants. However, many important natural areas remain in private ownership.

Despite the protection and environmental stewardship shown by many long-term landowners, a steady incremental reduction in the remaining forest area[6] was observed between 1995 and 2007 due to ongoing land clearance (Golders, 2007) which was identified as a key issue that required future management.

2.5 Plantation forestry

A very small portion of the Kāwhia catchment, approximately 1%, is used for exotic forestry (Figure 9), mainly for growing and harvesting of *Pinus radiata* (radiata pine). Plantation (or exotic) forests have been established in predominately erosion prone steep hill country or dune systems. Recent new forestry is concentrated in upland rural areas of north-east Kāwhia, in addition to extensive sand dune plantation planting along Raukumara Beach. Kāwhia based Tainui Kāwhia Incorporated became the first Māori incorporation to buy out the Crown's interest in a Māori lease forest in November 1997. The forest covers an area of 1000ha situated on the sand dunes by Kāwhia Harbour (most of the forest sits outside the catchment boundary) and provides employment for the local community.

Plantation forestry can have soil conservation benefits until trees reach maturity in a 25-30-year harvest cycle. Plantation forestry can however have a potential environmental cost. Steep slopes within the Kāwhia catchment that are highly susceptible to landslides for 6 to 8 years post-harvest can degrade streams, with loss of shade, bank destabilisation and deposition of slash and other material during rain events (Singleton, 2018).

[5] Held under conservation legislation, e.g., the Conservation Act 1987, and Reserves Act 1977.
[6] From comparison of the NZMS 260 series topographical maps and aerial photographs in 2008.

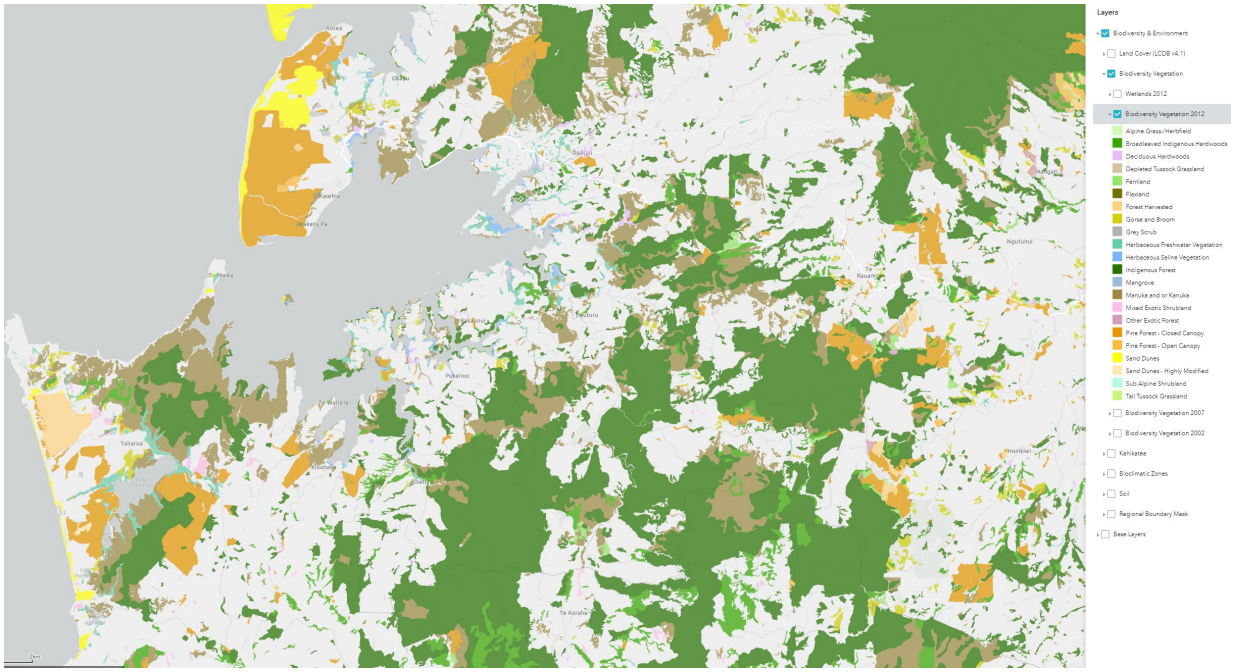


Figure 9. Snapshot of biodiversity vegetation layer 2012, with plantation forest in the Kāwhia catchment shown in orange.

Any operations in forests are required to be conducted under the National Environmental Standard for plantation forestry (NES-PF) that came into effect in May 2018; however, local Councils retain the ability to regulate specific areas outside the NES-PF, such as Significant Natural Areas or Outstanding Landscapes, when more stringent rules are required to give effect to other National Policy Statements such as the NPS on Freshwater Management or the New Zealand Coastal Policy Statement. To address climate change and in response to meeting Kyoto Protocol requirements central government has developed a New Zealand Emission Trading Scheme, focused on the trade of carbon credits to offset carbon emissions.

The Shore Futures report finalised in 2009 documented the opportunity for areas of marginal land to be retired in forestry, which would be recognised as a store of carbon. If done in accordance with the necessary requirements from central government, these areas will be accorded carbon credits, which can then be traded through the Emission Trading Scheme. This is a further economic opportunity for the management of land in the Kāwhia catchment (Environment Waikato, 2009).

2.6 Farming

Farming related land cover makes up approximately 69% of the Kāwhia catchment, including high and low producing grassland used for mostly dry stock and a small amount of dairy farming. Farming can adversely affect the catchment if eroded soils and farm runoff enters adjacent rivers and streams and nutrients, sediment and pathogens are transported through the water network. The Kāwhia catchment has a high proportion of farmed land on class 6e land, and this land is prone to erosion. Farming may therefore exacerbate naturally occurring erosion rather than creating a new environmental stressor. Maintaining grass cover and identifying areas on farm prone to erosion and controlling the erosion are very important.

The effects of farming can be mitigated through good farm management. Well-managed waterway margins, grassed farm drains, seepage areas and wetlands help protect water quality. These mitigation measures filter surface runoff, remove nitrogen and prevent stock access (when fenced). Many of

these mitigation measures are implemented in the Kāwhia catchment with a particular focus on riparian management of pastoral waterways.

Most riparian margins in the Waikato region are dominated by pastoral grasses, instead of the more desirable woody vegetation[7] which offers greater ecological and biodiversity benefits (Norris et al. 2020). Ideally riparian vegetation should include a combination of non-woody (e.g. sedges and flaxes) and woody (trees and shrubs) vegetation, incorporating indigenous species.

Waikato Regional Council surveyed the riparian margins of more than 300 stream reaches across the region in 2002, 2007, 2012, and 2017, to assess and track changes in the extent of fencing, vegetation and erosion in riparian margins within pastoral land. In the 2017 survey, approximately 40% of the bank length of the region's waterways in pastoral land were unprotected from stock access at that time (Norris et al. 2020).

The report by Norris et al. (2020) identified the West Coast zone as the area of the region with the lowest proportion of riparian margins with effective fencing (28% of bank length), the highest proportion of surveyed bank length with evidence of stock access (84%), and the second highest incidence of stream bank erosion (23%). As such the West Coast has been identified as the area that would benefit most from future riparian fencing efforts and stock exclusion.

Graeme (2014) observed that there had been notable progress with riparian fencing and planting on some properties around the Kāwhia Harbour between 2005 and 2012, but that considerable opportunities for improvement remained. A focus on small to medium-sized waterways (including drains with respect to the restoration of woody vegetation and the establishment of wider riparian margins) would be of particular benefit (Jones et al. 2016).

2.7 Tourism

The catchment provides opportunities for boating, fishing, swimming and other ocean activities. Kāwhia hot water beach is also a main tourist attraction of the catchment. Over the summer months the population can become much larger than the permanent resident population. This creates pressure on many aspects of the catchment, particularly on water and roading infrastructure, rubbish, navigation in the harbour and popular tourist destinations within the catchment.

[7] Woody vegetation is more desirable because of its: role in regulating stream water temperature (via shading); contribution to stream-bank stability, and additional biodiversity benefits (e.g. bird habitat).

3 Erosion and sediment

3.1 Overview of sediment-related issues in waterways

The steep hills, unstable geology and high rainfall in the Kāwhia catchment make it naturally vulnerable to erosion. Some land uses, including farming which is prevalent in the catchment[8], exacerbate erosion risk, particularly along waterway margins. The eroded areas produce sediment and are slow to recover. Erosion can have several physical impacts on fence lines, culverts, tracks and other infrastructure (Singleton, 2018).

Sediment naturally occurs in waterways, however excess sediment can increase water turbidity (make water cloudy), infill streams and estuarine embayment's, smother shellfish beds, and change sandy habitats to muddy ones. The change from sandy to muddy substrate or high turbidity reduces people's enjoyment of water. Excess sediment can also reduce the diversity and productivity of habitats. Aquatic fauna diversity decreases with an increase in mud, and benthic vegetation, such as seagrass, may not be able to tolerate elevated turbidity or mud deposition. Sediment is also a major carrier of contaminants, including nutrients (particularly phosphate) and bacteria. Erosion from farmland can thus pose health risks for people swimming in downstream waters. In urban runoff, sediment can also carry chemical and organic contaminants.

In this section we describe the main sources and exacerbators of sediment-related issues and how they impact water bodies within the Kāwhia catchment. Additional information on suspended sediment in rivers and streams is provided in section 4.2 and suspended sediment in Kāwhia Harbour is discussed in section 4.3 below.

3.2 Sources of excess sediment

The main sediment issues for Kāwhia are generated in the hills of the upper catchment. Studies have shown that the root systems of trees increase soil strength by 30% or more compared to pasture (described in Singleton, 2018), and hence many landslips have occurred since the historic deforestation of the catchment. Storm events with moderate intensity can now cause erosion, while much greater storm intensities were required to cause slips in forests. Replacement of much of the forest with pasture has widened the moisture range of the soils and caused greater drying out of the surface, which increases the risk of erosion. The hill country has high rainfall (between 1,600 - 2,500 mm per year) in the headwaters and is prone to shallow slip and sheet erosion, particularly where heavy livestock are grazed on steep land.

Large areas of the hill country in the catchment also have high erosion risk and sediment yield (section 1.3 above). Effective soil conservation is critical for maintaining its health.

3.3 Suspended sediment in rivers and streams and loads entering Kāwhia Harbour

Waikato Regional Council regularly monitors the water quality of 14 streams within the West Coast Zone, including the Oparau River, which falls within the Kāwhia catchment (see Figure 11 in section 4).

Water clarity trends were assessed for all long-term routine monitoring sites in 2018, both in terms of turbidity and baseflow water clarity, including in the Oparau River for the period 1993-

[8] See section 2.6,

2017 (25 years) and 2008-2017 (10 years). The results are shown for the Oparau River in Table 3, which shows that based on Waikato Regional Council guidelines water clarity can generally be described as satisfactory. There were no notable trends for turbidity over the two time periods but there was a likely improvement in water clarity over the 10 years from 2008-17 at a rate of 2.2% per year.

In a review of 2017 monitoring data, turbidity was excellent for one (1), satisfactory for seven (7), and unsatisfactory for the remaining five (5) sampling visits. Visual clarity was satisfactory at five monthly sampling events and less than satisfactory for the remaining six (6) sampling visits[9] (Vant, 2018).

A preliminary study of the loads of contaminants carried by eight streams in the Kāwhia catchment in 2006 (Figure 10) showed that suspended sediment loads increased significantly during wet weather, to approximately 180 times the low flow loads (Vant, 2019). Table 4 shows the suspended sediment loads of the eight surveyed rivers and streams during the 2006 study period. The study confirmed that the five largest rivers and streams contributed most (>98%) of the suspended sediment in the catchment. Survey sites were located near but at varying distances from Kāwhia Harbour. These survey results therefore provide an approximation of suspended sediment loads entering Kāwhia Harbour and the relative influence of individual rivers and stream on suspended sediment loads into the harbour.

In this 2006 study the Oparau and Awaroa Rivers were the highest contributors of water flow to the harbour (Table 4). However in proportion to flow, the Oparau River carried considerably less suspended sediment than the Awaroa River.

These results indicate that, in terms of suspended sediment, the water quality of the Oparau River is likely better than other streams and rivers within the catchment. This is consistent with the higher relative proportion of indigenous vegetation remaining within the Oparau catchment.

These results also indicate that the water quality monitoring results from Oparau River (which are described more comprehensively in section 4.2.1 below) are likely not representative of all rivers and streams in the rest of the Kāwhia catchment.

Table 3. Turbidity and water clarity in the Oparau River in 2017. Results shown in the context of WRC guidelines and change (% per year) over 25 years (1993 to 2017) and most recent 10-years (2008 to 2017). Only trends with slope direction probability >95% are specified; others are described as 'No likely trend'. Sources: Tulagi (2018), Vant (2018).

Parameter	2017 monitoring results			WRC guidelines[10]		Annual change (slope direction probability, %)	
	Median	Min	Max	Satisfactory	Excellent	1993-2017	2008-2017
Turbidity (NTU)	3.3	1.6	240	<5	<2	No likely trend	No likely trend
Baseflow water clarity (m)	1.60	0.04	2.79	>1.6	>4	No likely trend	2.2 (97%)

[9] Of 11 black disk measurements taken in 2017

[10] www.waikatoregion.govt.nz/environment/natural-resources/water/rivers/healthyrivers/how-we-measure-quality/

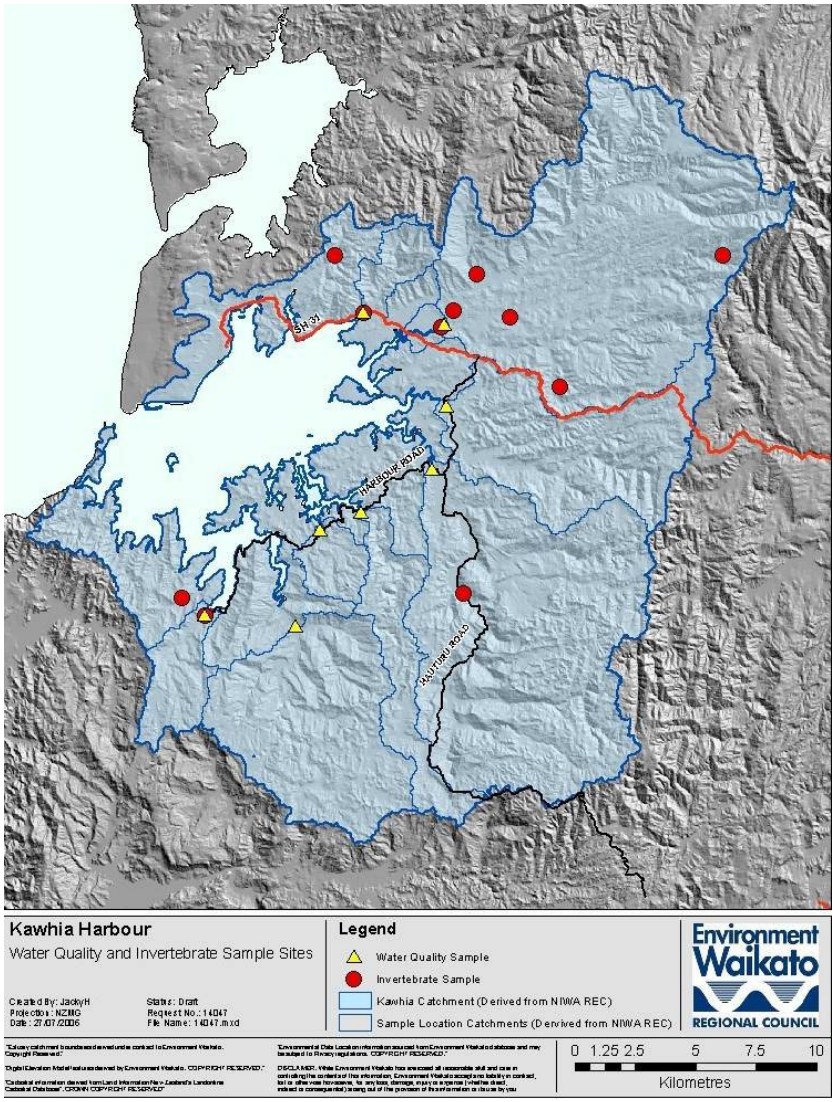


Figure 10. Sites in the Kāwhia catchment sampled in 2006 (yellow triangles are sites discussed in this report).

Table 4. Flows and suspended sediment load in eight streams in the Kāwhia catchment on two occasions in 2006, representing low flow and high flow conditions. For each occasion, the sum of all flows and loads are shown (in bold), together with the percentage contribution at each location. Source: Vant (2019).

	Flow (m^3/s)	Suspended sediment (g/s)
Low flow (23 January 2006)		
Sum across all sites	**4.7**	**47**
Awaroa	38%	53%
Oparau	28%	8%
Mahoe	15%	20%
Te Kauri	10%	15%
Ngahuina	5%	2%
Oteke	2%	1%
Awaawaroa	1%	1%
Kawaroa	<1%	<1%
High flow (7 August 2006)		
Sum across all sites	**47.8**	**8636**
Awaroa	29%	56%
Oparau	36%	21%
Mahoe	14%	5%
Te Kauri	10%	13%
Ngahuina	6%	3%
Oteke	3%	1%
Awaawaroa	1%	<1%
Kawaroa	1%	<1%

3.4 Sediment yields in Kāwhia Harbour

An estimate of sediment yields within wider Waikato estuaries was published in 2004 (Mead and Moores, 2004). This study estimated a sediment yield of 98,000 tonnes per year from the catchment into Kāwhia harbour, which was the sixth highest ranking (for relative sediment yield) of all 29 estuary catchments in the Waikato region at that time. The report notes that sediment yield from the catchment is only part of the process leading to sedimentation in estuaries, as tidal flushing plays a key part in determining how much of the sediment input from the catchment is retained in the estuary (Mead and Moores, 2004).

Kāwhia Harbour is 'strongly flushing', which means that most of the water that comes into the harbour from the rivers goes out to sea in one tidal cycle. Whilst most of the water is taken out to sea, sediment can be deposited in the sheltered arms of the harbour (Greer et al., 2016), and there is concern about the increasing "muddiness" of the harbour. Catchment river flows are proportionally small compared to the volume of harbour, so water circulation and mixing within the harbour is dominated by the tide.

3.5 Sediment contaminants in Kāwhia Harbour

Sediment contaminants, such as metals and other trace elements, have both natural and man-made sources. Most of these elements are found in small amounts in the earth's crust. When volcanic rocks containing these elements are weathered and erode in the catchment, trace elements enter the marine sediments and naturally occur there.

Pressures on estuaries increase as population numbers grow and developments increase both in catchments and coastal areas. Inter-tidal flats and their associated communities are highly susceptible to changes in land use and other activities in catchments. Mining, urban and industrial activities can cause input of trace elements and organic compounds into estuaries which may be stored in the sediments. The sediments then become a potential source of trace elements and organic compounds to animals and plants both in the sediment and the overlying water.

A description of sediment quality within the Kāwhia Harbour (and other west coast estuaries) concluded that the concentration of trace elements appeared to be more elevated in sediments near river mouths as compared to sediments found in the centre of the harbour or near the harbour mouth. The concentrations of most trace elements[11] were at the lower end of the estimated natural range (Rumsby, 2009).

The levels of copper, lead, zinc, mercury, nickel, silver, chromium, cadmium and antimony were well below ANZECC guidelines. Level of arsenic were slightly elevated at one site, possibly as the result of a geothermal hotspot. The sediment quality in Kāwhia Harbour (as well as Aotea and Whāingaroa harbours) was assessed as “good” and indicated a low risk of toxic effects on sediment dwelling organisms at that time.

[11] with the exception of arsenic near the Kāwhia settlement

4 Water quality

4.1 Introduction

Waikato Regional Council routinely monitors a representative cross-section of regional rivers and streams to assess the suitability of water quality for native water plants and animals, including the Oparau River in the Kāwhia catchment. Waikato Regional Council is also undertaking water quality monitoring in Kāwhia Harbour and has carried out targeted investigations into water quality of waterbodies in the catchment. The following sections provide a description of water quality in the catchment's rivers and streams as well as the harbour.

4.2 Freshwater quality within the catchment

4.2.1 River and streams

In the Kāwhia catchment monthly freshwater monitoring has been conducted since 1993 at the Oparau River at Langdon Road. Monitored parameters assess ecological health (temperature, dissolved oxygen, pH, different forms of nitrogen, different forms of phosphorus) and the suitability of water quality for human use (faecal bacteria *E. coli* and enterococci).

Waikato Regional Council's Environmental Indicators website provides summary data for the 2016-2020 period (Figure 11, Table 5) and this information indicates that the Oparau River was not considered to be safe for contact recreation (swimming) over that period. This was due to high levels of *E. coli* (100% of the time) and unsatisfactory clarity (at baseflow) measurements (42% of the time). The Oparau River met standards for ecological health most of the time (Table 5), with some unsatisfactory measurements of temperature, turbidity, and plant nutrients (nitrogen and phosphorus).

Figure 11. Average (2016-2020) results of monitoring (ecological health and suitability for swimming) at the Oparau River monitoring site as displayed at the Waikato Regional Council Environmental Monitoring Hub website.[12]

[12] https://www.waikatoregion.govt.nz/environment/natural-resources/water/rivers/water-quality-monitoring-map/.

Table 5. Waikato Regional Council's environmental indicator summary data for the Oparau River (2016-2020).

		Oparau River - % of samples during 2016-2020 that meet the following standard		
		Excellent	**Satisfactory**	**Unsatisfactory**
Contact Recreation	Baseflow Clarity		58.33%	41.67%
	E. coli (95th percentile)			100%
Ecology	Ammonia	100%		
	Dissolved Oxygen	100%		
	pH	94.83%	5.17%	
	Temperature	27.59%	53.45%	18.97%
	Total Nitrogen	5.17%	84.48%	10.34%
	Total Phosphorus	22.41%	68.97%	8.62%
	Turbidity	32.76%	32.21%	31.03%

Water quality at the Oparau River monitoring site is slightly better compared to other West Coast stream sites, including other streams in the Kāwhia catchment, which may reflect the rather higher proportion of the catchment covered by indigenous forest (Vant, 2019)

A trend analysis of water quality data monitored at the Oparau River site between 1993-2017 (24 years) revealed the following trends at that time (Tulagi, 2018; Vant, 2018):

a. A very likely deteriorating trend (at a rate of 0.5% per year) in total nitrogen.
b. A very likely improving trend (at a rate of 1% per year) in total phosphorus.
c. Fluctuating water clarity with a possible improvement between since 2008, but no consistent trend over the monitoring period; and
d. No likely trends in dissolved oxygen and ammonia and data were insufficient to identify trends in *E. coli*.

The most recent information about the current state and trends of water quality at the Oparau River site is presented on the LAWA website[13]. This site allows comparison of individual sites to all monitoring sites as well as to comparable sites, in the case of Oparau River to other lowland rural sites.

The state of and trends in water quality indicators measured at the Oparau River site are shown in Table 6 as the median of measurements made between 2019 and 2023, the National Policy Statement for Freshwater Management 2020 (NPS-FM) attribute band[14] (where applicable), the state of this site in comparison to other lowland rural sites in New Zealand, and trends over the 10-year period 2014-2023.

As described above water quality at the Oparau River site can be described as relatively good over this period (based on the NPS-FM attribute band and relative comparisons to other rural lowland sites) in terms of nitrogen and phosphorus and moderate in terms of clarity.

[13] https://www.lawa.org.nz/explore-data/waikato-region/river-quality/oparau-river/oparau-river-at-langdon-rd-off-okupata-rd/

[14] LAWA evaluates state (current conditions) from river sites nationwide against attribute bands described in the NPS-FM 2020, from A (good) to D or E (poor). These bands are explained at https://www.lawa.org.nz/explore-data/waikato-region/river-quality/oparau-river/oparau-river-at-langdon-rd-off-okupata-rd/

However, in terms of *E. coli* the classification is attribute band D, meaning that 20-30% of the time, the estimated infection risk for swimmers is >=50 in 1000 (>5% risk) and the predicted average infection risk is >3%[15]. The 10-yearly trend for *E. coli* is 'very likely degrading' (Table 6).

Overall, streams in the West Coast are, generally, of reasonable quality in comparison to other parts of the Waikato region that have more intensive land use. Figure 12 provides spatial contour plots using water quality data from four parameters, based on median values for the last five years for the regional water quality monitoring (Salu, 2021). *E. coli* is a parameter of concern for the Kāwhia catchment. It is at levels that pose a realistic risk to swimmers and is high when compared to other sites in the Waikato region as well as other lowland rural sites in New Zealand.

Table 6. Water quality state as a five-year median (2019-2023), National Policy Statement for Freshwater Management 2020 (NPS-FM) attribute band and comparison to other New Zealand lowland rural sites for the Oparau River monitoring site. Source: LAWA website, accessed 14 March 2024).

Indicator		5-year median (2019-2023)	NPS-FM attribute band	Comparison to all NZ lowland rural sites	10-year trend
Bacteria	*E.coli*	200 n/100ml	D	In the worst 50%	Very likely degrading
Clarity	Black disc	1.51 m	A	In the best 50%	Indeterminate
	Turbidity	3.2 NTU		In the worst 50%	Likely improving
Nitrogen	Total Nitrogen	0.234 mg/L		In the best 25%	Likely degrading
	Total oxidised Nitrogen	0.096 g/m^3		In the best 50%	Likely improving
	Ammoniacal Nitrogen	0.01 mg/L	A	In the worst 50%	Likely degrading
	Nitrate Nitrogen	0.096 mg/L	A	In the best 25%	Likely improving
Phosphorus	Dissolved Reactive Phosphorus	0.005 mg/L	A	In the best 25%	Very likely improving
	Total Phosphorus	0.016 mg/L		In the best 50%	Very likely degrading

[15] As per LAWA website, the predicted average infection risk is the overall average infection to swimmers based on a random exposure on a random day, ignoring any possibility of not swimming during high flows or when a surveillance advisory is in place. Actual risk will generally be less if a person does not swim during high flows.

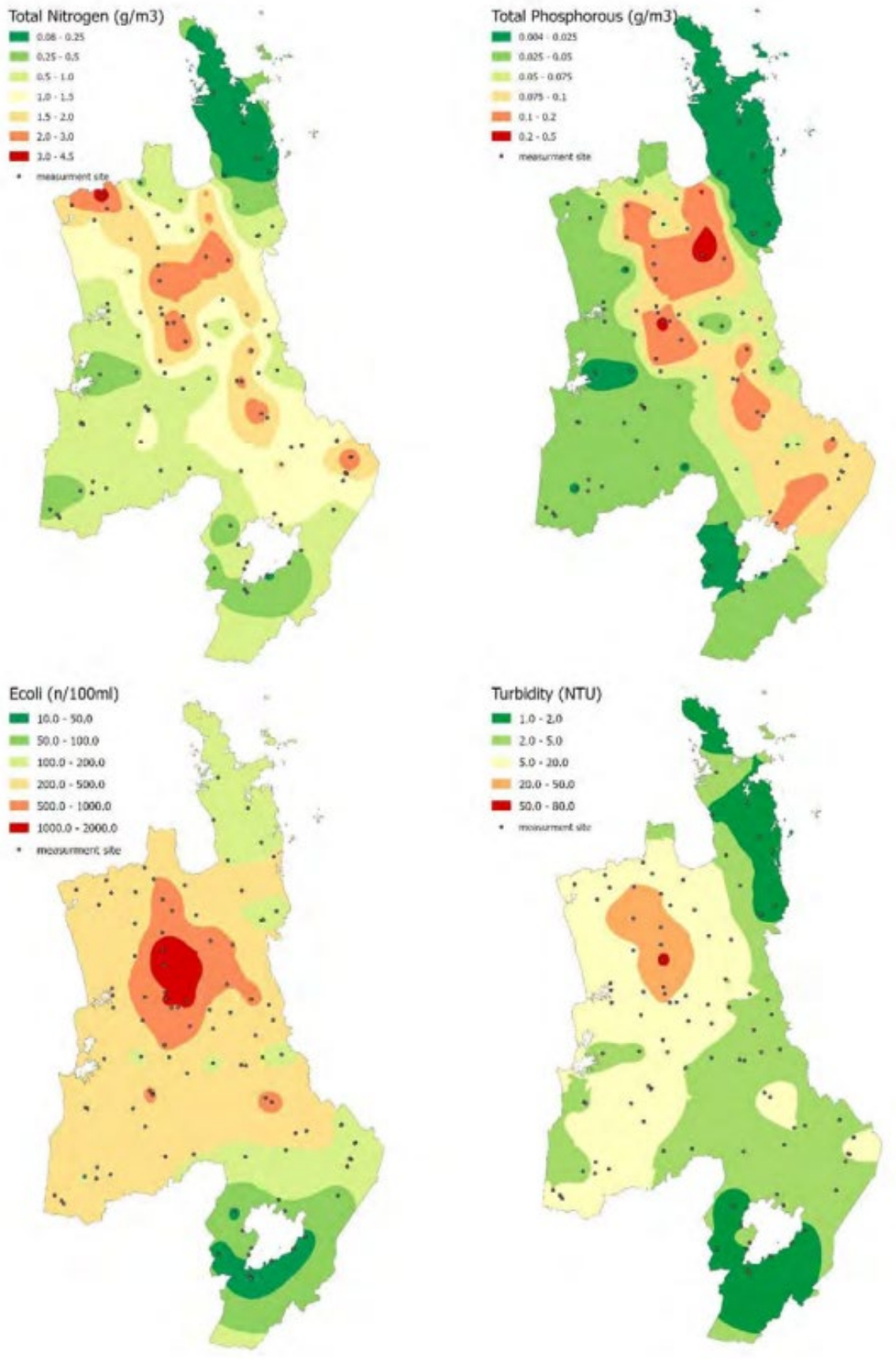


Figure 12. Spatial contour plots of four water quality parameters (based on 5-year median values, 2016-2020); Total Nitrogen, Total Phosphorus, Escherichia coli, Turbidity.

4.2.2 Contaminant loads in rivers and streams and loads entering Kāwhia Harbour

Total nitrogen, total phosphorus, and *E. coli* loads in eight Kāwhia rivers and streams were measured during low and high flow conditions during 2006 (Table 7). The five largest rivers and streams carried most (>92%) of the contaminants and therefore carry the largest of contaminant loads to Kāwhia Harbour (Vant, 2019).

As discussed in section 3.3, some rivers carry disproportionately (to flow) high or low contaminant loads. The Oparau River carried disproportionally low total phosphorus and E. coli loads. Total phosphorus loads were disproportionally high for the Mahoe and Te Kauri Rivers during low flow and the Awaroa and Te Kauri Rivers during high flow. E. coli loads were disproportionally high for the Mahoe River during low flow and the Awaroa and Te Kauri Rivers during high flow.

Section 4.2.1 outlined that E. coli levels are of concern at the Oparau River monitoring site. This comparison of rivers and streams indicates that E. coli levels at other streams in the Kāwhia catchment, specifically the Awaroa, Mahoe, and Te Kauri Rivers, may be considerably higher, at least during certain flow conditions.

Table 7. Flows and loads of contaminants in eight streams in the Kāwhia catchment on two occasions in 2006, representing low flow and high flow conditions. For each occasion, the sum of all flows and loads are shown (in bold), together with the percentage contribution at each location. Source: Vant (2019).

	Flow (m^3/s)	**Total N (g/s)**	**Total P (g/s)**	***E. coli* (cfu/s)**
Low flow (23 January 2006)				
Sum, all sites	**4.7**	**1.1**	**0.09**	**26**
Awaroa	38%	28%	34%	39%
Oparau	28%	22%	17%	11%
Mahoe	15%	25%	23%	30%
Te Kauri	10%	11%	15%	11%
Ngahuina	5%	7%	5%	3%
Oteke	2%	3%	3%	2%
Awaawaroa	1%	4%	2%	2%
Kawaroa	<1%	<1%	1%	2%
High flow (7 August 2006)				
Sum, all sites	**47.8**	**44.8**	**8.06**	**222**
Awaroa	29%	31%	48%	43%
Oparau	36%	34%	25%	17%
Mahoe	14%	10%	6%	7%
Te Kauri	10%	13%	14%	24%
Ngahuina	6%	6%	4%	5%
Oteke	3%	4%	1%	2%
Awaawaroa	1%	1%	<1%	1%
Kawaroa	1%	1%	1%	1%

4.2.3 Groundwater

There is little information available about groundwater resources in the Kāwhia catchment. Ōtorohanga District Council holds a resource consent to take up to 600 cubic metres of groundwater per day for the Kāwhia community water supply.

4.2.4 Summary - Freshwater quality

Overall, water quality in rivers and streams in the Kāwhia catchment is of reasonable quality in comparison to other parts of the Waikato region that have more intensive land use. In terms of total nitrogen and phosphorus water quality can be described as relatively good and in terms of water clarity as moderate. *E. coli* levels in several rivers and streams are of concern for the Kāwhia catchment. Summary data from the long-term monitoring site at the Oparau River for the 2016-2020 period indicated that over that time the Oparau River had *E. coli* levels that were unsatisfactory for contact recreation (swimming) 100% of the time.

Waikato Regional Council has also surveyed other rivers and streams in the catchment. The Oparau River makes the largest flow contribution to the harbour, compared to other inflowing rivers, but carries less contaminants (suspended sediment, total phosphorus, and *E. coli*) than some of the other rivers, especially the Awaroa River. This means that monitoring results from Oparau River are likely not representative for some parts of the catchment and that especially the Awaroa River is likely in a worse state than the Oparau River. Run-off and leaching from pastoral land use is the main source of contaminants to the harbour, which is exacerbated during wet conditions.

4.3 Coastal water quality within the catchment

4.3.1 Water quality monitoring overview

Most of the information presented in this section covers results of:

a. Water quality (ecological health) monitoring undertaken between July 2008 and July 2009.
b. Water quality (ecological health and suitability for recreation) monitoring undertaken between April 2019 and March 2021 (preliminary results of the three-year sampling period 2019-2022 under the estuarine water quality monitoring programme); and
c. Recreational water quality monitoring in sampling periods 1994-1997 and 2001-2009.

Prior to this, water quality surveys were more sporadic.

The most recent estuarine water quality monitoring was undertaken monthly at six locations at Kāwhia harbour (Te Kauri, Te Toi, Waiharakeke, Mixed, Mangaroa[16], and Oparau) between April 2019 and March 2022 (Figure 13) to determine the state and trends of water quality for ecological health (Kamke, 2021). The programme collected physicochemical data such as temperature, dissolved oxygen, salinity, turbidity, total suspended solids, chlorophyll a, nutrients (nitrogen and phosphorus) and microbiological parameters (enterococci, *E. coli* and faecal coliforms). Prior to this, water quality monitoring was undertaken between July 2008 and July 2009 at four sites around Kāwhia harbour (Site 1 - Site 4[17], Figure 13).

4.3.2 Estuarine water quality monitoring (ecological health)

Based on the most recent analysed monitoring data (2019-21), most of the sites were well oxygenated and mixed, however, in October 2019 the bottom waters of the Oparau site indicated oxygen

[16] same as Site2 Surface from 2008-2009 sampling
[17] including surface and bottom samples

depletion (<5 mg/L; approx. 50% saturation) and in November 2019 oxygen was <7mg/L (approx. 75% saturation). These values are below ANZECC guidelines[18] and can cause oxygen stress to aquatic organisms when present for prolonged periods or over an extended area. It has been recommended that the persistence and extent of low oxygen zones should be further investigated if further oxygen depletion events occur at the Kāwhia sites.

Water clarity was usually good in Kāwhia Harbour, with median turbidity values better than ANZECC guideline values at all stations in the most recent monitoring period. In the 2008/2009 monitoring period, Sites 1 and 3 exceeded turbidity guideline values. Median secchi disc readings at outer harbour sites (Mangaroa and Te Toi) generally had better readings (>1 m) than inner harbour sites (0.6 - 0.9m).

Chlorophyll values were better than ANZECC guideline values at all stations and at all times. Inner Harbour values were generally slightly higher than outer harbour stations in 2019-2021, peaking in Sep-Feb. The highest median chlorophyll-a values were recorded at Oparau, which could explain the low bottom water dissolved oxygen values at this station as increased primary production fuels the growth of aquatic organisms and oxygen consumption.

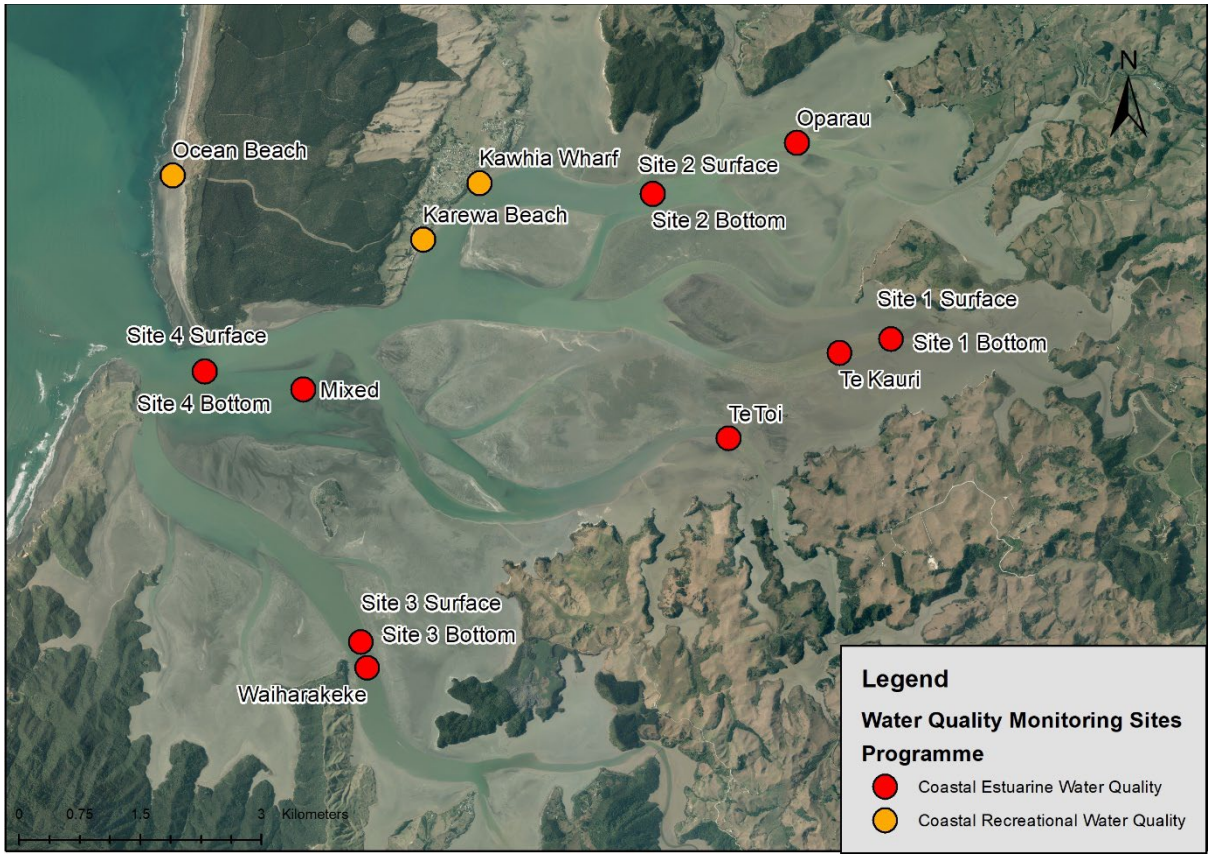


Figure 13. Map showing locations of estuarine (red dots) and recreational (orange dots) water quality monitoring stations at Kāwhia Harbour.

[18] The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) guideline values are considered thresholds that are based on reference site data from South-East Australia. For estuarine monitoring stations falling under the slightly disturbed category (considered most appropriate for most New Zealand estuaries), the potential risk for adverse ecological effects is considered low if water quality data at monitoring sites remains within the threshold boundaries. Above those values, it is recommended that further investigation of ecological impacts of water quality are conducted. It is important to note that ANZECC guidelines are based on data from South-East Australia waters only, as no New Zealand-specific data was available at the time of development. Thresholds may therefore not represent New Zealand specific conditions but are currently the most suitable option for guideline values.

Total nitrogen values were below guideline criteria at least 50% of the time over all monitoring periods and stations. Site 1 in 2008/2009 and Oparau and Te Toi in 2019-2021 exceeded the guidelines more than 25% of the time. Exceedances occurred outside of summer months only (March - September) which may reflect nutrient input due to land runoff and river discharges in the wetter months. All median ammoniacal nitrogen values from the 2019-2021 monitoring period were above guideline limits with the strongest exceedances in winter months and no clear differences between monitoring stations. Similarly, nitrate and nitrite nitrogen values increased during winter.

Median total phosphorus values in 2008/2009 at Site 1 and Site 3 exceeded guidelines values, except for one outlier, whilst measurements at all stations since 2019 were consistently under guideline values. However, more than 75% of dissolved reactive phosphorus measurements between 2019 and 2021 exceeded ANZECC guideline values for all stations except Mixed. In 2008/2009 for most stations the 25th percentile total phosphorus value was below guideline values for all stations except Site 1, where median values exceeded guideline limits. Exceedances were consistent throughout the year but highest during winter months.

While monitoring for some stations started more than ten years ago, monitoring has not been continuous. Changes in the locations of the stations monitored, monitoring parameters, and the analysis methods restrict the ability to compare data over space and time. Ultimately this lack of consistency restricts the analysis and possible interpretation (Kamke, 2021).

4.3.3 Suitability of estuarine water for contact recreation and shellfish gathering

During water quality sampling in the period 2019-2021 (described in the previous section), the water quality in Kawhia harbour was often suitable for contact recreation based on concentrations of faecal indicator bacteria. The Ocean Beach (Figure 13) monitoring station was least impacted as can be expected from a highly dynamic location with high flushing ability. Monitoring stations in the harbour were slightly more impacted but exceedances were limited to single events (Kamke, 2021). Water sampling is limited to monthly due to logistical challenges of reaching the station more frequently. While the reduced frequency may limit the ability to detect exceedances, current results demonstrate a high suitability for contact recreation.

Kamke (2021) reported that shellfish gathering water quality may be slightly more impacted as the 90th percentile guideline limit was breached in the past in the inner harbour locations. Due to the lack of current monitoring at the required weekly frequency focused on the shellfish gathering season there in no information about the current water quality state for shellfish gathering.

In addition to the sampling described in the previous section, water quality was monitored at three stations, Karewa Beach, Kāwhia Wharf and Ocean Beach (Figure 13), to assess the suitability of estuarine water for contact recreation and shellfish gathering with sampling from 1994-1997 for enterococci[19] and every second season from 2001-2009 for enterococci and faecal coliforms[20]. Weekly monitoring was also undertaken between November 2015 and February 2016 as part of a regional study of coastal water quality across the region. The monitoring included a single sampling point within Kāwhia Harbour near the main Kāwhia settlement and one on the open coast north of Taurahatahi Point. Over this period, recreational water quality guidelines were met, indicating a high suitability for contact recreation in those areas (Waikato Regional Council unpublished data, 2017).

[19] As an indicator of the suitability for contract recreation in saline waters.
[20] As an indication of the suitability for shellfish gathering.

4.3.4 Tide gauge monitoring

WRC currently operates a tide gauge network to measure tidal and extreme sea levels in the Waikato region. Water levels are also continuously monitored at the Kāwhia Wharf (tidally influenced) and reported via the WRC website. In addition to water levels, other data such as wind speed, wind direction, atmospheric pressure and water temperature (or a subset) are monitored at each location (Hunt, 2021).

Hunt (2021) reported annual analysis of the tidal record shows no long-term inter-annual variability in tidal constituents and therefore although the tidal signal is modified compared to the open coast the tidal signal has been broadly consistent at this location over the duration of the record. Despite the historical stability of the tidal signal, there may be future changes in tidal characteristics from morphological changes in the estuary and rising sea level.

4.3.5 Summary - Coastal Water Quality

Estuarine water quality monitoring generally showed good water quality with high clarity and no major signs of eutrophication in Kāwhia Harbour. Kāwhia Harbour is well oxygenated, has good water clarity, low phytoplankton (chlorophyll a) levels, and low total phosphorus. Occasional elevations in total nitrogen occurred during winter. More than 75% of dissolved reactive phosphorus measurements between 2019 and 2021 have exceeded the ANZECC guideline values for all sites except one. Exceedances were consistent throughout the year but highest during winter months.

Recreational water quality sampling showed that water has been suitable for recreation but water quality for shellfish gathering may have been impacted after rain. Current monitoring is too infrequent to fully inform recreational water quality but indicates that water quality continues to be suitable for recreation.

Overall estuarine water quality in Kāwhia Harbour appears to experience mild pressures from nutrients which were most prominent in winter months and inner harbour sites. Harbour water quality reflects that of rivers and streams in the catchment, with overall good water quality but with declines during winter and wet weather events when rainfall in the catchment increases contaminant loads in rivers and streams that reach the receiving harbour waters, including microbial contaminants, which may create a health risk to people swimming or gathering shellfish during these times.

4.4 The three waters: drinking water, wastewater and stormwater

Associated with rural and urban settlements and infrastructure development are the three waters: drinking water, wastewater and stormwater. During the summer period demand on water infrastructure is at its highest, but the catchment also can experience fluctuating demands. This can present challenges for the provision of water infrastructure, both in terms of providing services to people and in regard to environmental effects.

4.4.1 Drinking water

Drinking water supply to housing within the Kāwhia township catchment is provided from two springs. Infrastructure underwent maintenance at the end of 2020 to improve performance during summer periods.

During population influx over the summer months water supply becomes limited requiring the Ōtorohanga District Council (ODC) to issue conservation messages to local residents and visitors.

Due to the absence of residential water meters, water loss (or non-revenue water) within the catchment is calculated through a minimum night flow calculation. Using this method, water loss is estimated at around 30%. The ODC has not been able to ascertain whether the unaccounted-for water is network related or within private property. As of January 2021, there were no current reported or identified network leaks. However is also noted that most of the reticulation is sitting within sand and a leak can go unnoticed unless it comes to the surface. This makes leak detecting difficult for ODC and residents (Ōtorohanga District Council 2021).

4.4.2 Wastewater

Households within the Kāwhia catchment rely on septic tank systems to manage wastewater. It has been identified by ODC that a new wastewater system is needed in Kāwhia to prevent pollution of groundwater and harbour waters from septic tanks and to allow for future growth, however inception would be largely reliant on government funding (Ōtorohanga District Council 2021).

4.4.3 Stormwater

Stormwater is the rainwater that drains off the land. Stormwater needs to be managed properly as it can otherwise flood roads, pose risks to public health and safety, property, or the ecological health of waterways. ODC collect and dispose of stormwater via resource consents covering their stormwater systems in the Ōtorohanga and Kāwhia urban areas to prevent/minimise flooding from heavy or prolonged rainfall events. The stormwater systems altogether comprise of 12.5km of pipes and 4km of open drains. Stormwater is directed away from properties and roads and is discharged into the Kāwhia Harbour. No information is available about the quality of stormwater discharge or the subsequent effects on the environment (Ōtorohanga District Council 2021), it is not. It is however noted that a low-risk non-compliance was recorded for the Kāwhia urban discharge consent during 2020-2021 compliance period. No further details could be found on the type of non-compliance (Ōtorohanga District Council 2021).

5 Biodiversity

5.1 Introduction

New Zealand's indigenous biodiversity has declined over time, particularly since human settlement. More than 200 indigenous plant and animal species are now under threat of extinction in the Waikato[21]. Threats to our biodiversity include introduced predators and pest species, conversion of land to farmland and degradation or loss of wetlands, dunelands, river and lake systems, and coastal areas. For more information about pests see section 6.

This section provides an overview on the state of biodiversity within the Kāwhia catchment, including terrestrial, freshwater, and estuarine.

5.2 Significant natural areas (SNA)

New Zealand still contains many natural areas that provide habitats for indigenous plant and animal species and provide important ecosystem services. Some of these natural areas contain threatened species or rare types of habitats that make them more important relative to other natural areas without these features. In the Waikato region these areas are called significant natural areas (SNA).

An SNA project has been in operation at Waikato Regional Council since 2006, with the aim to identify, rank, and determine the management requirements of these sites of high biodiversity value in the region, largely focussing on terrestrial areas (Wildlands Consultants Ltd., 2016). Figure 14 displays the terrestrial SNA identified in the Kāwhia catchment.

Waikato Regional Council identifies and prioritises[22] SNA to:

a. protect natural heritage for future generations.
b. protect sufficient habitats to provide habitat for threatened species[23].
c. link up or re-connect SNAs to improve their health; and
d. fulfil its obligations under the Resource Management Act 1991[24].

[21] www.waikatoregion.govt.nz/environment/natural-resources/biodiversity/indigenous-biodiversity-programme/
[22] according to its level of significance (international, national, regional or local)
[23] To prevent extinction
[24] The Resource Management Act (RMA) 1991 requires regional and district councils to protect "areas of significant indigenous vegetation and significant habitats of indigenous fauna"

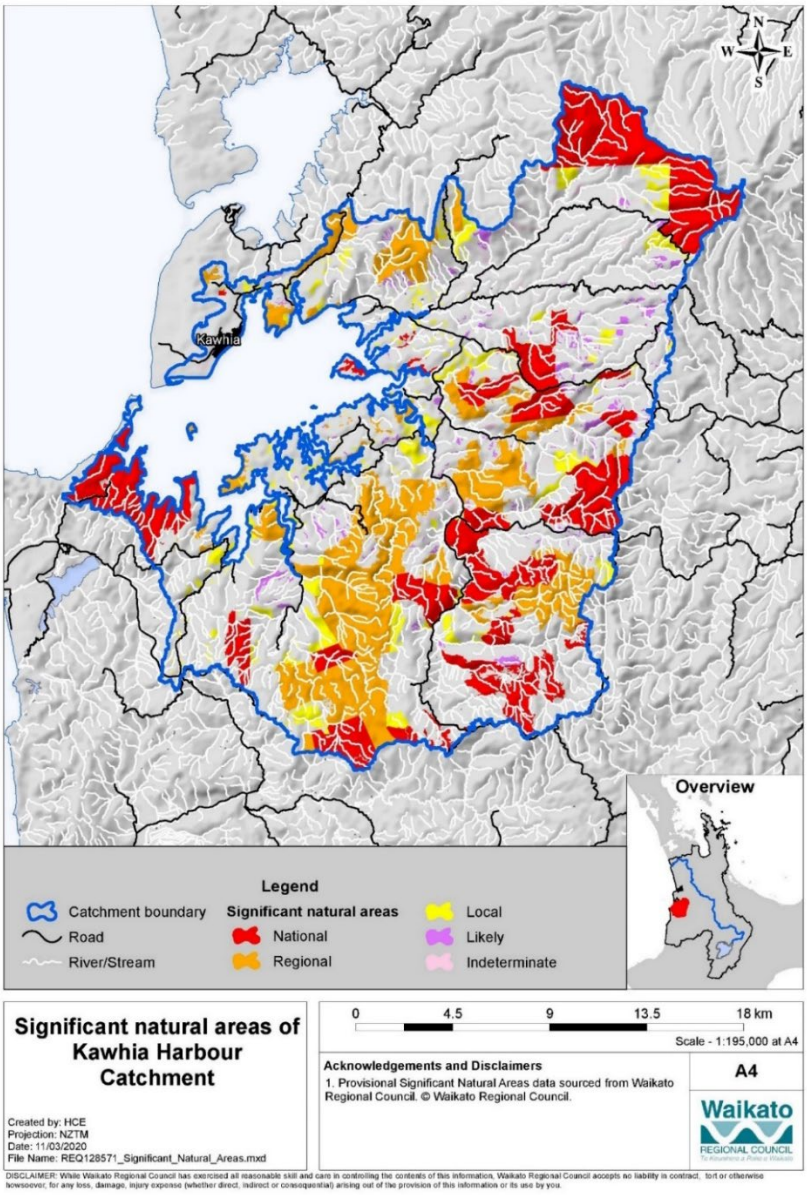


Figure 14. Terrestrial significant natural areas (SNA) in the Kāwhia catchment (Singleton, 2018).

5.3 Terrestrial vegetation

The original vegetation of the Kāwhia Ecological District and the extent of change that has occurred since human settlement is described in Harding (1997) and Wildlands Consultants Ltd. (2014).

In the past most of the catchment would have been entirely covered in indigenous vegetation: 70% of this was primary forest; 27% secondary forest, scrub and tussock land, 1.1% duneland habitat, and 1.4% wetland habitat. Species included extensive rimu-tawa forest cover extended over the hill country, with more broadleaved species present at coastal sites, and kauri occurring in isolated stands within the Te Kauri Stream catchment. Conifer-broadleaved forest dominated at higher (montane) altitude with dense podocarp forest at low altitude alluvial sites. Extensive duneland vegetation occurred around the entrances to Aotea and Kāwhia harbours, while freshwater wetland areas were present to a lesser extent.

Despite the extent of modification, the Kāwhia catchment retains some extensive and important areas of indigenous vegetation, and numerous smaller areas that are critical for a number of rare and

threatened species and are nationally important examples of their type (e.g. karst). In many instances these areas have been retained as a result of legal protection (e.g. public conservation land), their isolated location, or the care of long-term landowners. However, some of these areas are vulnerable to further reduction as a result of ongoing land clearance (as per Golder Associates, 2007), further land use change and intensification, exotic species, and habitat modification.

The Kāwhia catchment and Kāwhia Ecological District (ED) support a number of rare and threatened species. Cromarty and Scott (1996) identified several locally uncommon plants from areas adjacent to the harbour, including:

a. *Pomaderris rugosa* and *Metrosideros carmine*.
b. An unusual association of whau in coastal forest.
c. *Hebe obtusata*, *Scandia rosaefolia* and *Empodisma minus* in the east.
d. King Fern or Para (*Marattia salicina*), *Doodia mollis*, and *Asplenium obtrusatum var northlandicum* around the southern inlets and peninsulas; and
e. *Scandia rosaefolia* at its southern limit on Motukaraka Island.

Likewise, Wildlands Consultants Ltd. (2014) lists 26 nationally threated or At Risk indigenous vascular plant and fungus species, three Regionally threatened or uncommon plant species, and six plant species with distributional limits within or near Kawhia ED. The Awaroa valley supports a number of rare and significant native plant species, including two mistletoe species (*Peraxilla tetrapetala and Tupei Antarctica*) and the endemic Awaroa koromiko (*Veronica scopulorum)* as seen in Figure 15*,* which is only known from a small number of limestone outcrops in the headwaters of the Awaroa River and northern Taumatatotara range (Brandon et al. 2004). The nationally vulnerable plant, Kirk's daisy (*Brachyglottis kirkii*) is also known to occur within the Kāwhia catchment. This fleshy small green usually epiphytic shrub has large white daisy-like flowers, and is targeted by possums, goats and deer.

Most natural areas within the Kawhia ED are surrounded by farmland and therefore are potentially at risk of clearance and stock incursions. Pest animals such as possums, goats, deer, and pigs are present, and pest plants such as grey willow and wilding radiata pine are also widespread (Wildland Consultants Ltd., 2014).

Figure 15. Awaroa hebe (*Veronica scopulorum*) is found on only a handful of rock outcrops in the partially forested karst landscape inland from Kāwhia.

Harding (1997) identified the following opportunities for future protection within the Kāwhia catchment:

a. a small remnant of privately owned podocarp forest east of Kāwhia harbour.
b. relatively large (unprotected) areas of rimu-tawa forest areas east and south of Owhiro adjoining Taumatatotara Forest; and
c. an important remnant area of unprotected logged tawa forest in the Owhiro Inlet of Kāwhia Harbour.

He also commented on the opportunity to protect important corridors of indigenous vegetation south and east of Kāwhia Harbour to connect isolated parts of Taumatatotara Forest through to Te Kauri Park Scenic Reserve to the north, Hauturu Forest and Pirongia South Forest in the east, extending to Pirongia in the northeast.

5.4 Karst sites

Karst is a limestone landscape with sinkholes, fluted rocky outcrops, disappearing streams, underground rivers, caves, natural bridges and springs, that develops because limestones made of calcium carbonate dissolve by rainfall over time.[25]

Initial work has been undertaken to identify significant natural karst areas and features within the Waikato region and collate information on their values. Work is underway to ground truth these sites and document their current condition.

The Kāwhia catchment contains a number of significant surface karst features, including the six top-ranked sites described below (Wildlands Consultants Ltd., 2014).

[25] See storymap about the management of karst landscapes in the Waikato region at https://storymaps.arcgis.com/stories/54ccf093bef8446badd0f3fe47adf096.

Coastal karst & lakes on Rakaunui peninsula.

The surface karst site is composed of twelve areas on the western shore of Kāwhia Harbour that cover a total area of 147ha. These areas, which range in size, are fragmented patches of native vegetation surrounded by farmland and exotic pasture. Some of the features occur within the coastal marine area (CMA), whilst others are on public conservation or private land. The area is described as one of the most spectacular examples of coastal karst in New Zealand that includes caves and partly submerged dolines (with swamps or small lakes) along the coast and sinkholes and blind valleys inland. There are areas of bush clad bluffs, rocky outcrops and pinnacles inland. Much of the area is coastal fringe vegetated bluffs, pinnacles and rocky outcrops. Caves are present in a number of places.

Te Kauri karst is a moderately (294ha) sized karst site occurring both sides of Kāwhia Road at Hauturu and includes naturally uncommon caves, cave entrances, and cliffs. The features occur on a mix of public conservation and private land. Te Kauri Reserve has mostly low-grade karst developed in calcareous Aotea Sandstone. Forested sandstone bluffs occur above some of the streams. The two best areas of karst are in the upper Muturangi Valley and in a tributary of the Wairakanui Valley. The site also includes 340m long Erebor Cave (Muturangi Valley) which has 400m of mainly stream passage and 290m long Wairakanui Stream Cave. Te Kauri Park is the southern limit of kauri-podocarp-broadleaf forest. The site is well vegetated with good condition native vegetation and is well-connected to larger forested areas within the locality.

Lake Koraha and Matauratahi. The site covers 43ha and includes Lake Koraha, which is a small (0.8ha) lake that is in excellent ecological condition. The lake drains through a small cave system (National Institute of Water and Atmospheric Research, 2015) and is surrounded by native forest (Dean-Speirs and Neilson, 2014). The area is partially in public conservation land with native vegetation that is in good condition and is well-connected to a larger, relatively intact patch of forest.

Awaroa rocky peaks and karst (aka ridge tors[26]) are a collection of limestone pinnacles that occur largely on public conservation land. The pinnacles range from 460m to 497m above sea level and include features known as Ngawhakatara (The Lady), Hauturukanekeneke (The Dome) and Otuatakahi (Knob Head) (Ryan et al., 2017). The indigenous vegetation is in good condition and well-connected to a larger, relatively intact patch of forest.

Taumatatotara karst and dolines which make up an extensive (519ha) karst site of three discrete areas on lowland and sub-montane areas, west of Te Koraha. The site contains dolines and blind valleys and includes the site of Taumatotara/Arch Cave. It.is well vegetated with native vegetation in good condition and well-connected to larger forested areas within the locality. The karst features occur partially on public conservation land and land protected by Ngā Whenua Rāhui (Department of Conservation) but are largely unprotected.

Kāwhia whenuapo (castle rock). A small (10.6ha) surface karst site composed of a plateau of karst and perched ephemeral lake. The karst area consists of a narrow rocky karstose ridge crest, that almost encircles three dolines, one with an ephemeral lake. There are numerous small caves and some pre-European stone fortifications. The features occur amongst native forest in the upper reaches of the Mataimarino Stream catchment. The native vegetation is in good condition and is well-connected to a

[26] A tor (aka castle koppie or kopje) is a large, free-standing rock outcrop that rises abruptly. [27] Moderately steep - 21-25 degrees slope

larger area of forest within the locality. The area occurs on private land and is partly protected by a Ngā Whenua Rāhui kawenata.

Most of these areas occur on a mix of public and private land and support a wide range of rare and threatened species. On public conservation land the major threats are the impacts of pest animals and weeds, and human visitors. The unprotected areas are also vulnerable to these factors, as well as further impacts arising from grazing and other agricultural impacts associated with rural land use.

5.5 Changes in terrestrial ecosystems within the Kāwhia catchment

Before European colonisation of New Zealand (c.1840), the Ōtorohanga District (which contains a large portion of the Kāwhia catchment) was almost entirely covered in indigenous vegetation. Since then, the combined effects of logging, land clearance, drainage, and fires have reduced indigenous vegetation cover in the District to approximately 28% of the 1840 extent (Leathwick et al. 1995). The most heavily reduced vegetation types are coastal, semi coastal, and lowland forests, which have been widely cleared for farming.

Coastal and lowland vegetation has been significantly affected as a result of clearance and development. Vegetation occurring at lower elevations and particularly floodplain vegetation has been largely removed for pastoral land development. The most recent biodiversity inventory data shows that most (81%) land less than 20 degrees slope, and half of the moderately steep[27] land in the Kāwhia catchment has been converted to pasture (WRC unpublished data, 2021).

Higher elevation areas, which are unsuitable for farming, have retained their indigenous character but have been modified by the removal (i.e. logging) of larger podocarp species. Several large blocks of indigenous forest remain - mostly in the steeper upland areas to the east and south-east, across and up long alluvial valley ridges, and in a broad swathe across the south harbour ridgeline (Golders, 2007). Coastal forest species include kohekohe, nikau, puriri and tawa. Semi-coastal forest occurs on the lower slopes of the hill country that is dominated by secondary podocarp and broadleaved forest (Environment Waikato, 2009).

To identify the remaining extent of land cover for different ecosystem types it is necessary to have an accurate inventory of both current indigenous vegetation and original coverage (the latter known as the Potential Ecosystem (PE) Layer developed by Singers and Rogers 2014). The average accuracy of the current biodiversity inventory data is ~60%[28], but will increase to >80% with work that is currently underway to verify the terrestrial vegetation data that WRC holds.

A map of potential ecosystems in the Kāwhia catchment is shown in Figure 16 and the codes used to identify ecosystem are explained in Table 8. A map of estimated[29] current ecosystems in the catchment is shown in Figure 17. The area coverage of each ecosystem type in the potential and estimated current ecosystems maps are also shown in Table 8 alongside the calculated percentage remaining, indicating the reduction or increase in all ecosystem types.

Comparing potential and current ecosystems highlights substantial reduction or loss of valuable ecosystems in the catchment. As a result, only 12% of the original kahikatea-pukatea forest remains today, and there is no longer any totara-kanuka-broadleaved forest or totara, matai, ribbonwood forest.

[27] Moderately steep - 21-25 degrees slope
[28] *Based on the WRC biodiversity inventory layer*
[29] The draft biodiversity inventory has not been ground-truthed and is therefore indicative only.

It is estimated that approximately half of the original wetland areas still exist, but much of what remain has been significantly affected by drainage, land development, farming, mining and stock encroachment. The data in Table 8 would indicate an increase in wetlands but this is largely due to re classification of vegetation types from the warm forest categories WF13 and WF8 to wetland categories.

Lowland podocarp forest made up a small proportion of the original vegetation within the Kāwhia ED but has been the most depleted. Almost all remaining rimu-tawa forest and montane conifer-broadleaved forest has been legally protected. Vegetation on the alluvial flats and dune land vegetation are heavily depleted within the Kāwhia ED (Wildlands Consultants Ltd., 2016). Almost all saline ecosystems, such as seagrass herbfields, mangrove forest and saltmarsh, have been lost. These ecosystems now only comprise very small areas of the catchment (Table 8).

Overall, the Kāwhia catchment still contains large areas of high biodiversity value, most notably the indigenous forests in the upper catchment and areas of scrubby manuka and kanuka, which can support further forest regeneration.

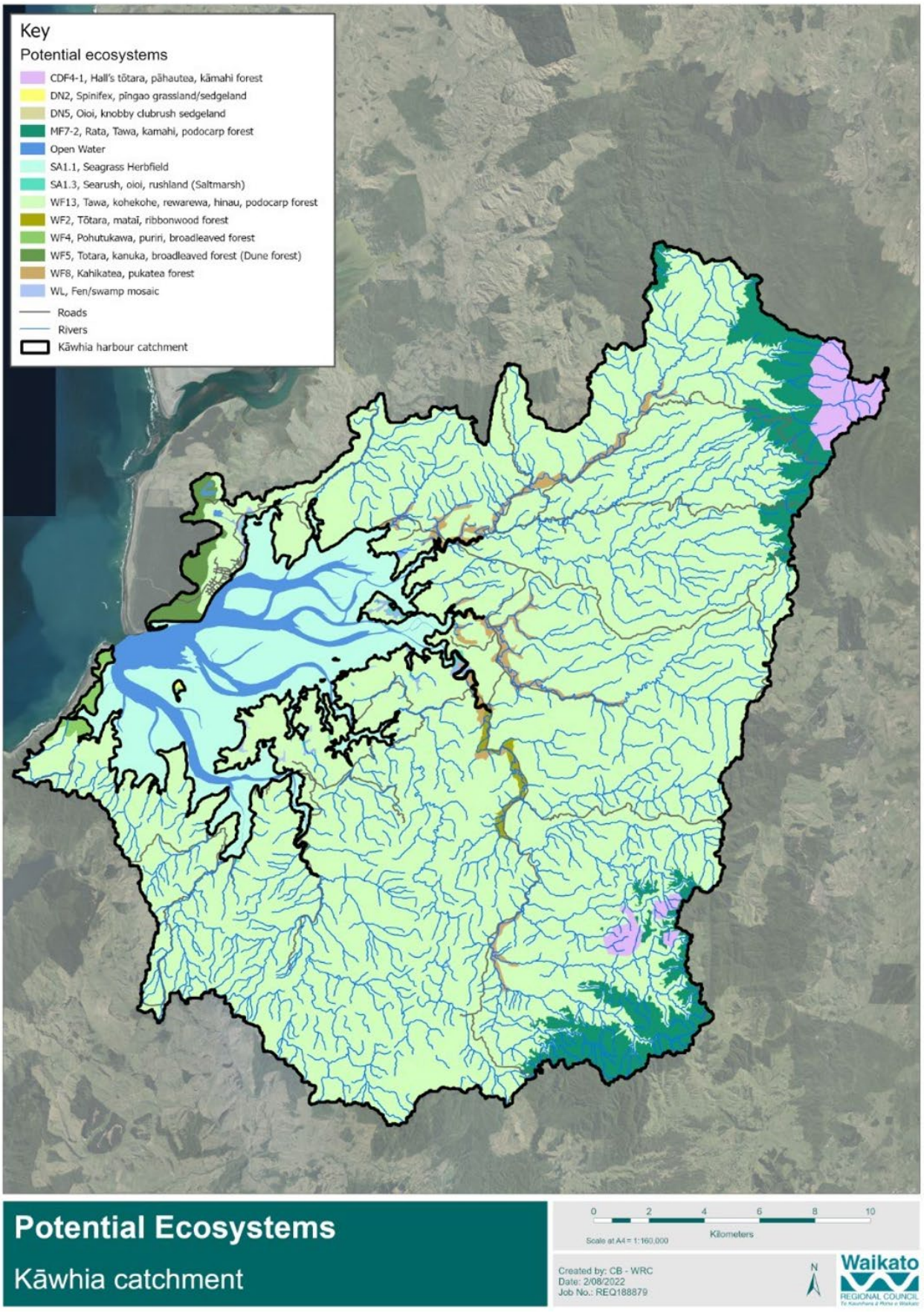


Figure 16. Potential ecosystems in the Kāwhia catchment.

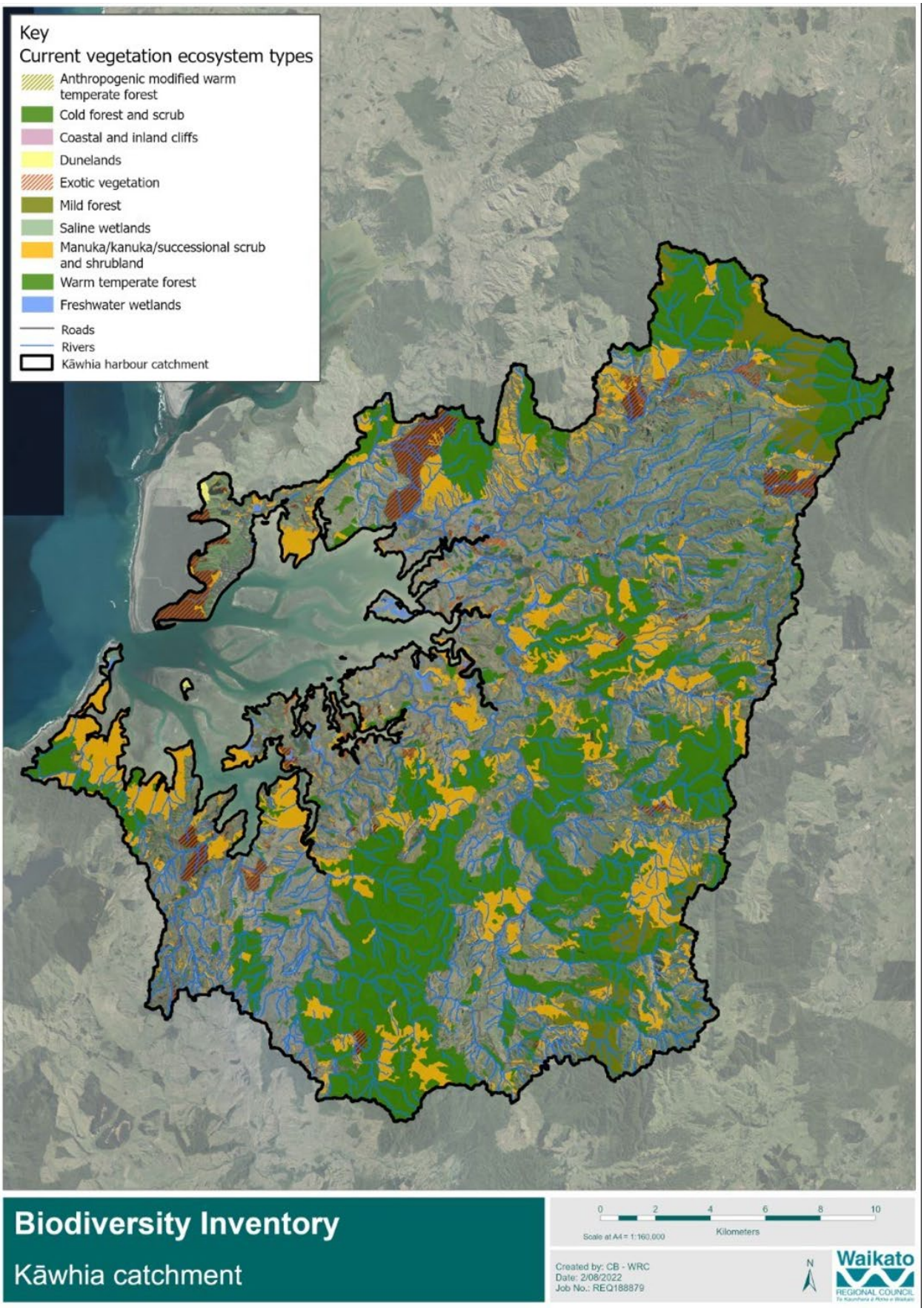


Figure 17 Draft biodiversity inventory for the Kāwhia catchment.

Table 8. Ecosystem types used to map potential ecosystems and the draft biodiversity inventory. The estimated potential and current area of each ecosystem type is shown as well as the percentage remaining today compared to the potential coverage. Colour codes are explained below the table.

Code	Ecosystem type	Potential Area (ha)	Current Area (ha)	Remaining (%)
Anthropogenic (A)				
AMF1	Anthropogenic tawa (human-induced tawa treeland)		2.40	
AWF1	Anthropogenic kahikatea forest		17.07	
AWF2	Rewarewa treeland		2.41	
Cold forest and scrub (CDF)				
CDF4-1	Hall's totara, pahautea, kamahi forest	847.89	623.80	73.57
Cliffs (CL)				
CL2	Ngaio, taupata treeland/herbfield/rockland		0.21	
Active coastal sand dunes (DN)				
DN2	Spinifex, pīngao grassland/sedgeland	13.02		0.00
DN2/5	Coastal Sand Dunes Mosaic		32.51	
DN5	Oioi, knobby clubrush sedgeland	3.11		0.00
Exotic (E)				
EF-FH	Forest Harvested		41.98	
EF-OEF	Other Exotic Forest		66.62	
EF-PFCC	Pine Forest - Closed Canopy		1181.40	
EF-PFOC	Pine Forest - Open Canopy		36.45	
EF-WIL	Willow		9.39	
ES-DHW	Deciduous Hardwoods		3.75	
ES-EGH	Exotic grassland, herbfield, rushland		144.64	
ES-GB	Gorse, Broom, pampas and woolly nightshade		177.39	
ES-MES	Mixed Exotic Shrubland		36.34	
Mild Forest (MF)				
MF7-1	Tawa mangeao forest		129.41	
MF7-2	Rata, Tawa, kamahi, podocarp forest	2851.66	1435.32	50.33
Saline (SA)				
SA1	Herbaceous Saline Vegetation		0.26	
SA1.1	Seagrass herbfield	87.15	0.96	1.10
SA1.2	Mangrove forest and scrub		0.03	
SA1.3	Searush, oioi, rushland [Saltmarsh]	134.09	127.77	95.28
SA1.6	Saltmarsh, ribbonwood, ngaio, akeake scrub		7.93	
SA1.7	Saline herbfield (sea meadow) - glasswort, sea primrose, half star, shore celery, sea rush, etc		0.04	
Vegetation Succession (VS)				
VS10	Fernland (bracken)		0.31	
VS16	Restoration/Revegetation - mixed native plantings		6.43	
VS17	Mixed native & exotic shrubland		193.89	
VS2	Kanuka scrub/forest		617.77	
VS2.1	Advanced regenerating podocarp with kanuka		182.52	
VS3	Manuka-Kanuka		2656.57	

VS3.1	Adv sec with regen conifers through Manuka-kanuka mosaic		48.75	
VS4	Manuka		159.00	
VS4.1	Adv sec with regen conifers through Manuka		3.30	
VS5	Broadleaved species scrub/forest mosaic/treefern scrub		1776.69	
VS5.1	Adv sec broadleaved forest - most kamahi		967.69	
VS5.2	Tree fernland		108.47	
Warm forest (WF)				
WF13	Tawa, kohekohe, rewarewa, hinau, podocarp forest	42378.44	13233.17	31.23
WF2	Tōtara, mataī, ribbonwood forest	168.16		0.00
WF4	Pohutukawa, puriri, broadleaved forest	163.54		0.00
WF4.1	Coastal/semi coastal, little or no Pohutukawa		96.07	
WF5	Totara, kanuka, broadleaved forest [Dune forest]	378.14		0.00
WF7-3	Kahikatea, puriri forest		13.91	
WF8	Kahikatea, pukatea forest	782.75	96.14	12.28
WF8/WL	Kahikatea, pukatea forest and Swamp mosaic		4.69	
Wetlands (WL)				
WL-FM	Fen mosaic	54.32	42.08	77.47
WL-HFW	Herbaceous Freshwater Vegetation		16.12	
WL-SFM	Swamp/Fen mosaic	85.77	7.32	8.54
WL-SM	Swamp mosaic	23.73	288.23	1214.71
Other	Other		8.97	

Absent	
<20% remaining (underrepresented in catchment)	
>20% remaining	
>Expected	

5.6 Rivers and streams

Before European settlement, New Zealand's rivers and streams flowed from the mountains to the coast through native forest and grassland communities. These forests and high-altitude grasslands kept smaller rivers and streams cool and shady. The clearing of this vegetation has made stream temperatures more variable, and less suitable for many of our native aquatic animals and plants.

In addition to habitat loss through land clearance, aquatic plants and animals have also been affected by other aspects of development including:

a. barriers to fish passage, such as over-hanging culverts and dams that can block access for the many native fish that travel between freshwater and the sea as part of their life cycle.
b. reduced water quality.
c. changes to flow regimes; and
d. habitat loss (due to drainage and changes in land use).

Furthermore, some introduced species become pests that compete with or eat our native species.

Biodiversity river prioritisation started on a national level and was then conducted on a regional scale for the Waikato region (Leathwick and Julian, 2009). The approach identified the highest value rivers most representative of a particular river type in the Waikato region based on stream geology, associated species, climate, and a range of other factors. The approach also included combining physical information with cost-benefit aspects of restoration. For example, sites that have DOC estate in headwaters are more likely to benefit from restoration than those with highly developed upstream environments. In the assessment, 38.89% of the Kāwhia catchment has areas identified as being significant - i.e. falling within the top 20% of sites identified within the Waikato region (Waikato Regional Council, 2016).

Rivers and streams identified as significant natural areas within the Kāwhia catchment are:

a. Oparau River, and some tributaries[30].
b. Awaroa River, and some tributaries[31].
c. Rangitaiki Stream.
d. Te Kauri Stream.
e. Opango Stream.
f. Waitapu Stream.
g. Waiharakeke Stream, and some tributaries[32]; and
h. Owhiro Stream.

Rivers identified through this method are in principle the best candidates for restoration/conservation. However, the prioritisation approach is mainly a desktop exercise and there will be features in the riverscape that were not considered but that affect outcomes. For this reason, sites and their upstream environments would need to be visited and assessed before any results shown here can be used to inform restoration/conservation activities.

5.7 Lakes

The Waikato Regional Council has more than 70 shallow lakes that provide for a wide range of values. They are also important as wildlife habitats, water supply, flood control, commercial and traditional fisheries, and recreation. These lakes also perform nutrient cycling and other ecosystem processes that contribute to the life supporting capacity of the wider environment.

To inform the future management of lakes in the Waikato region, Waikato Regional Council has prioritised and ranked known lakes and identified future management actions for these lakes - including Lakes Koraha, Parangi and Te Rotopupu in the Kāwhia catchment (Wildlands Consultants Ltd., 2011; Dean-Speirs & Neilson 2014). Further details on these shallow lakes are provided below.

5.7.1 Lake Koraha

Lake Koraha is a small (0.8ha) karst lake that is in excellent ecological condition. The lake occurs on conservation land and most of its catchment (c. 70%) is in native vegetation. The lake drains through a small cave system and is surrounded by native forest. DOC have an active programme to eradicate royal fern from a wetland on the margin of the lake (Dean-Speirs & Nielson 2014).

In 2015, DOC and WRC contracted NIWA to assess the ecological condition of the lake. This study confirmed the importance of Lake Koraha as a rare example of a small but un-impacted low-land karst lake system. The native aquatic plant community of Lake Koraha is categorised in 'excellent' ecological

[30] including Mangahanga and Otungaoko Streams.
[31] including Te Awaiti, Paparoa, Otuatakahi, Pirorua and Kaimango Streams.
[32] including Puaroa, Mahoe and Kotanemoeroa Streams.

condition (a LakeSPI[33] Index of 97%) and currently represents the highest scoring water body in the Waikato Region and the second highest nationally[34]. Future management actions for the lake involve regular monitoring and surveillance, and careful management of access to the lake to prevent the establishment of invasive submerged plants (Burton & Smith 2015).

5.7.2 Lake Parangi

Lake Parangi is a privately owned 12-hectare dune lake that is located between Kāwhia and Aotea harbours in a primarily pastoral catchment. Lake Parangi has moderate-high wildlife values, and still supports submerged (mostly exotic) vegetation that is likely to be threatened by deteriorating water quality. Lake Parangi was monitored by Waikato Regional Council in 2007/08 when its water quality was poor (Dean-Speirs & Neilson 2014).

5.7.3 Lake Te Rotopupu

Lake Te Rotopupu is a small (c.1 hectare) privately owned dune lake. Very little was known about the condition of the lake during the development of Council's Shallow Lakes Management Plan, so it was identified as a priority for assessment to determine its condition and future management requirements (Dean-Speirs & Neilson 2014). Because the catchment of the lake is mostly pastoral, the water quality of lake Te Rotopupu is likely to be vulnerable to deterioration.

Te Rotopupu was also identified as a top-ranking wetland for restoration in the Nga repo o Kāwhia project that was part of joint study undertaken by NIWA and Maniapoto Māori Trust Board to identify significant wetlands (repo) and springs (puna) and prioritise them for restoration based on Mātauranga-a-iwi, values, uses, associations, resources and opportunities (Ratana et al. 2019).

5.8 Kāwhia Harbour

Kāwhia Harbour is a large estuary that extends over 6,765 hectares and contains five bays. Estuaries provide essential ecosystem services and contribute to critical processes that influence ecosystem health and water quality, including clarity, nutrient cycling, and sediment stability. Estuaries also provide habitat for species that are important food resources for humans, fish, birds, and other species (Hillock and Rohan, 2011).

Dowding (2019) notes that Kāwhia Harbour is listed as a wetland of international importance under Ramsar criteria by Cromarty & Scott (1996). The harbour meets the criteria because of its importance to international and internal migratory birds. The harbour is nationally important[35] as a wintering site for indigenous and international shorebirds, including pied oystercatchers, black stilts, banded dotterels and pied stilts (Hillock and Rohan, 2011).

The coastal waters and margins of Kāwhia Harbour have been assessed to have Outstanding Natural Character (Boffa Miskell Limited, 2016). Key values include the remote and ecologically important harbour and bush margins and the unmodified and spectacular coastal landforms that are recognised to retain outstanding degrees of naturalness and contain a diverse range of ecological biota.

The harbour is also identified as an Area of Significant Conservation Value (ASCV) in the Waikato Regional Coastal Plan for a range of reasons including (but not limited to):

a. outstanding habitat for wildlife, wading, shore and wetland bird fauna.
b. extensive eel grass communities; and

[33] Lake Submerged Plant Indicators
[34] In comparison to 252 lakes assessed using LakeSPI
[35] Meeting the criteria for national importance of supporting 1% or more of a national population.

c. the presence of (resident and visiting) rare and threatened wading and coastal bird species; and the presence of Maui dolphin.

Approximately 74% of Kāwhia Harbour is exposed at low tide. While the harbour is well flushed, sediment can be deposited in the sheltered arms of the harbour (Greer et al. 2016), and there is evidence of sediment accumulation within the harbour resulting from catchment inputs which has been associated with the degradation, habitat modification and the loss of some shellfish beds (Hillock and Rohan 2011).

5.9 Shorebirds in Kāwhia Harbour

Kāwhia Harbour has been identified as a site of importance to shorebirds and seabirds by Dowding (2019) who describes the following observations:[36]

a. South Island pied oystercatcher (At Risk, typically has 3000-5000 birds in winter, c. 3-5% of the global population).
b. Pied stilt (typically about 500 birds in winter, >1% of the NZ population).
c. Black stilt (Threatened, several individuals in all winters, >1% of the NZ population).
d. Variable oystercatcher (At Risk, resident and breeding).
e. Northern New Zealand dotterel (At Risk, typically 3-5 pairs breeding).
f. Banded dotterel (Threatened, winter flock of 300-400 birds, >1% of the NZ population, in top ten wintering sites in New Zealand).
g. Eastern bar-tailed godwit (At Risk, 3000-6000 annually, >1% of the NZ population).

The harbour and its margins also provides important habitat for banded rail (*Gallirallus philippensis*) and spotless crake (*Porzana tabuensis*) which are both ranked Sparse. Other species include black-fronted tern *(Chlidonias albostriatus)* which is Nationally Endangered and Caspian tern (*Hydroprogne caspia*) which is Nationally Vulnerable.

The bar-tailed godwit (kuaka) is the most common of the international migratory shorebirds. Other international visitors that occur in smaller numbers include the ruddy turnstone, whimbrel and far eastern curlew (Cromarty & Scott 1996).

Bird counts have been undertaken annually at Kāwhia harbour since 1976 by the Ornithological Society of New Zealand (now Birds New Zealand). Kāwhia harbour ranks eighth highest as a nationally important wintering site for New Zealand pied oystercatchers (*Haematopus finschi*), second for black stilts (*Himantopus novaezelandiae*), tenth for banded dotterels (*Charadrius bicinctus bicinctus*). It is also a nationally important site for pied stilts (*Himantopus leucocephaslus*) and New Zealand dotterels[37], and is visited by royal spoonbills (*Platalea regia*) (Dowding & Moore 2006; Cromarty & Scott 1996).

Four west coast sites including Kawhia Harbour have been ranked as a priority 1 site in a recent report by Dowding (2019). To be a priority 1 site it has to regularly hold 1% of the global population of one or more species or subspecies that are classified as Threatened or At Risk under the New Zealand Threat Classification System List for 2016.

[36] Threat status of birds reflect classifications under the New Zealand threat classification system lists in 2016 (Robertson et al. 2017) as reported in Dowding (2019).
[37] New Zealand dotterels have a significant breeding population at Kāwhia (Cromarty & Scott, 1996).

Kāwhia Harbour supports extensive tidal flats and areas of saltmarsh wetland on the fringes and in tidal arms of the harbour. These areas support rare and threatened wetland birds including banded rail, Australasian bittern (matuku) and North Island fernbird.

The harbour provides important feeding and roosting grounds for large (and increasing) populations of waterfowl, including black swan and Canada geese, that utilise the harbours during moulting. There is widespread concern about their impacts on the ecology of the harbour because of their grazing pressure on seagrass communities. There is also some concern about their indirect impacts on sea grass and wider harbour ecology through trampling, increased turbidity, eutrophication via deposition of faecal matter, and wider ecological effects including impacts on indigenous birds[38], and dispersal of undesirable plants and animals (Smith 2019).

Dowding (2019) reports that the main short-term threats to resident species are predation, disturbance during breeding, and natural factors, such as flooding of nests. In the longer term, loss, and degradation of habitat (from both natural and human-induced causes) will affect both resident and migratory species.

5.10 Aquatic fauna in the Kāwhia catchment

5.10.1 Shellfish in Kāwhia Harbour

Shellfish perform important ecosystem services in estuaries. They form a key component of shorebird and fish diets and are a significant source of mahinga kai for mana whenua.

In 2008, the Department of Conservation (DOC) mapped the distribution and abundance of cockles and wedge shells in intertidal areas of Kāwhia and Aotea harbours and recorded the presence and abundance of other species and habitat types including seagrass. Cockles were abundant in both harbours and were the most common species sampled in Kāwhia harbour, occurring in the highest densities in muddy sand substrates[39]. Wedge shells were the second-most numerous species and were recorded in greatest numbers from the middle of Kāwhia Harbour (Hillock and Rohan, 2011). This study observed extensive areas of deep mud in areas of Kāwhia Harbour which are not suitable habitat for cockles and other shellfish.

The loss of filter feeding organisms can have a profound impact on water quality. Cockles feed by pumping water across their gills and filtering out food particles at per-animal rates of up to 3 L per hour for 2 hours each side of high tide (Grant & Hay 2003). Based on the results of their survey, Hillock and Rohan (2011) estimated that cockles within the sampled area of Kāwhia Harbour could potentially filter up to 108 million litres during each tidal cycle[40]. The removal of these organic particles from the water column is likely to result in increased harbour water clarity and quality. Improved water clarity may enable greater plant growth due to greater light penetration for photosynthesis.

5.10.2 Freshwater fish and macroinvertebrates

Waikato Regional Council monitors the ecological health of rivers within the Kāwhia catchment as part of its River Ecological Monitoring in Streams (REMS) Programme. In this programme, macroinvertebrate and stream habitat is assessed at four sites annually, within the Awaroa River, and Mangahoanga, Omanawa Stream and Waikuku Streams. Further sampling occurs at three sites that are sampled once in each 3-year period; Pirorua Stream, and two sites on the Okupata Stream.

[38] including disease risk and competition

[39] Cockles were found in areas with and without seagrass

[40] based on the average density of cockles per quadrat, which equate to a total of 9M cockles within the surveyed area, and using the equation in Walshe et al. 2005

Results indicate that the state of the four river and stream sites is assessed as excellent to good based on their macroinvertebrate community index (Table 9). Trends are mostly improving, indicating little risk of negative change. Results are available from the LAWA website https://www.lawa.org.nz.

Many of New Zealand's native freshwater fish require unimpeded migratory access to the sea and back to complete their lifecycle. As a result, they are extremely sensitive to catchment changes, and most New Zealand species have undergone substantial population declines as a result of habitat modification and loss. The Kāwhia catchment supports a diverse number of diadromous native fish species that undertake these migrations between the coast and the forested headwaters of many of the inflowing streams and rivers. Instream habitat for these species can be affected by a range of factors, including:

a. Sedimentation reducing water quality, the amount of available habitat[41], and smothering spawning sites and fish eggs. Good sediment management within the catchment to minimise sediment loads into rivers and streams is thus important for supporting our freshwater fish biodiversity.
b. Fish Passage through the catchment being restricted by inappropriate structures (including culverts and fords) in waterways. National guidelines have been developed for the design of instream infrastructure to provide for fish passage[42].
c. Changes in river and stream water quality, including temperature[43]. Instream temperatures are directly related to the amount of riparian vegetation/shading that is available. Riparian vegetation is a key component of restoration projects and has considerable benefits for freshwater fish and invertebrates.

Table 9. Results from the Regional Ecological Monitoring of Streams (REMS) Programme undertaken within the Kāwhia Catchment between 2014-2022 (www.lawa.org.nz).

Site	Macroinvertebrate Community Index (MCI)*			Taxonomic Richness	%EPT***
	5 y median	National Objective Framework (NOF)** attribute band	Trend (10 y)	5 y median	5 y median
Awaroa River (@ Hauturu Rd bridge)	119.4	Band B (mild organic pollution or nutrient enrichment)	Indeterminate	27	52
Waikuku Stream @ Te Kauri lodge	130.6	Band A (pristine condition with almost no organic pollution or nutrient enrichment)	Indeterminate	22	53
Omanawa Stream tributary @ Pirongia West Rd	140	Band A (pristine condition with almost no organic pollution or nutrient enrichment)	Likely improving	28	67
Mangahoanga Stream @ Moerangi Rd	113.8	Band B (mild organic pollution or nutrient enrichment)	Likely degrading	28	52

* Higher MCI score indicates better stream conditions.

** As per the National Policy Statement for Freshwater 2020 Appendix 2B Table 14 National-Policy-Statement-for-Freshwater-Management-2020.pdf (environment.govt.nz)

[41] Including by filling interstitial spaces on the stream bed
[42] www.niwa.co.nz/static/web/freshwater-and-estuaries/NZ-FishPassageGuidelines-upto4m-NIWA-DOC-NZFPAG.pdf
[43] which directly affects oxygen saturation levels, and the toxicity of a range of contaminants

*** EPT are macroinvertebrates that are sensitive to water pollution. These are Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly).

To monitor the state of freshwater fish populations in the region, Waikato Regional Council developed a standardised fisheries sampling programme in wadeable streams in 2009, and added routine fisheries sampling to the existing REMS programme in 2011/2012 (David et al., 2016). This involved establishing a network of 160 sites across the region that are fished at least once every 3 years.[44]

The data that has been collected provides a baseline of information to monitor 'state' (and any changes over time) to better inform policy development and management decisions. It is likely that the data from the REMS invertebrate and fish monitoring programmes will be amalgamated, and that metrics will be developed in future to provide a much more comprehensive and holistic assessment of the state and health of the Waikato wadeable river network.

5.10.3 Freshwater mussels (kākahi or kāeo) in wadable streams and rivers

New Zealand has three species of native (and endemic) freshwater mussel (kākahi or kāeo), *Echyridella menziesii*, *Echyridella aucklandica* and *Echyridella onekaka*. These play an important functional role within ecosystems and are recognised as a cultural keystone species[45]. However, all three species have been classified as "Nationally Vulnerable" or "At Risk" under New Zealand's threat classification system (Grainger et al. 2014).

To monitor freshwater mussel populations, Waikato Regional Council has developed a standardised protocol for wadeable streams and rivers (Melchior et al. 2023), which has been applied in five catchments of the Waikato region between 2013-2017. The result of this work indicates that freshwater mussels generally occur in low densities, with a few exceptions where dense populations occur.

E.menziesii has been found to be the most common species in Kāwhia, and occurring in eight out of 18 surveyed sites within the catchment, but were most numerous in the Okupata and Te Kauri Streams, where they also co-existed with *E.aucklandica* (that has a far more limited distribution).

Work so far suggests that the main factors that influence the presence of freshwater mussels are the presence of silt, runs, and bank habitat. Size structure was investigated and appears to show aging populations for both species with little sign of juvenile recruitment.

5.11 Aquatic flora in the Kāwhia catchment

5.11.1 Wetland vegetation

Wetlands are biologically rich and important natural features that occur between land and water, and are characterised by local conditions (hydrology, soils and vegetation). Wetlands provide a number of beneficial services for people and for fish and wildlife including protecting and improving water quality; providing fish and wildlife habitats; storing floodwaters, and maintaining surface water flow during dry periods.

As in the rest of New Zealand, wetlands have been reduced and lost from the Kāwhia catchment as a result of drainage and historical land use changes. Although substantially reduced already, there is evidence that wetland loss has also continued in recent times, despite policies and rules that were intended to protect them. Analysis of wetland areas between 1992-2005 indicate that the West Coast zone lost (through complete drainage[46]) approximately 7% of its wetland extent over that time. This is

[44] With the exception of 15 reference sites that are visited annually.
[45] because of their cultural importance (as a taonga species and a source of mahinga kai) for Māori
[46] This does not include wetlands that have been only partially drained or altered

considerably more (proportionally) than the c.1% loss experienced by the rest of the region as a whole (Kelly and Fenton 2012).

Wetland habitats are nationally and regionally under-represented as a result of the extent of loss that has occurred. Graeme (2005) observed that all remaining freshwater wetlands and swamp forest that adjoin estuarine systems in the Kāwhia catchment should be actively preserved and enhanced because of their scarcity and habitat value.

The following wetlands were identified as significant within the Kāwhia catchment:

a. Significant estuarine and freshwater wetland complex including Tiritirimatangi Peninsula wetland and the wetlands in the upper reaches of the peninsula's eastern and Awaroa arm, that are identified to have high wildlife and vegetation values.
b. Wide diversity of estuarine vegetation and remnant freshwater wetland habitats associated with the Owhiro Stream; and
c. Limestone outcrops and mature native forest/swamp forest around Rakaunui Inlet (Graeme 2005).

Maniapoto Māori Trust board and NIWA undertook a collaborative project to develop an inventory of wetlands (repo) and springs (puna) for the Kāwhia rohe (Ratana et al. 2017 and 2019) on the basis of their mātauranga-a-iwi, values, uses, associations, resources and opportunities for restoration. Utilising their framework, seven initial sites were identified as Priority Tuatahi (priority one) for restoration efforts:

a. Te Rotopupu (repo), Manua Swamp (repo), Ruatuna (repo), Repo (name to be confirmed).
b. Te Puia o Tawhia (puna), Te Kauri (puna), Puna (name to be confirmed).

5.11.2 Estuarine Vegetation

Estuarine vegetation such as salt marsh, mangroves and seagrass provide shelter, food, breeding and nursery grounds for animals such as fish, birds and shellfish. These habitats also act as filters, trapping sediment, nutrients and other contaminants, which improves estuarine water quality. Estuarine vegetation can also stabilise sediments and buffer the land from wave action, which helps to reduce coastal erosion.

The estuarine vegetation of Kāwhia harbour includes mangroves[47], salt marshes, seagrass, sea meadows and weed communities and their occurrence is describe and mapped in Figure 18 and Figure 19.

Mangroves (*Avicennia marina* var. *resinifera*) occur within Kāwhia harbour in sparse pockets at the southern-most limit of their distribution in New Zealand. These occur in small numbers in sheltered muddy locations. The extent of mangroves has previously been mapped but due to the small extent the map is of limited value to display.

Saltmarshes are composed of mixtures of low-growing herbs (sea meadows)[48], rushes[49] and sedges[50]. Graeme (2005 and 2014) observed that saltmarsh is extremely limited in extent (i.e. has a very narrow

[47] at their southern-most limit in New Zealand
[48] e.g. glasswort, sea primrose
[49] e.g. sea rush
[50] e.g. oioi, knobby clubrush

habitat range) but is highly significant within Kāwhia harbour. Figure 18 shows the saltmarsh extent within the Kāwhia harbour.

a. Sea meadows generally occur as thin bands or mixed with rushland along the upper tidal zone. A few large communities were also found seaward of rushland communities at stream mouths.
b. Sea rush and oioi are the dominant rushland species, with three common locally. In 2012 some areas of rush die back were observed which was discussed by Graeme (2014), and possibly attributable to changes in wind and wave exposure following control of adjacent areas of spartina; or the effects of stock grazing and pugging[51].
c. Large saltmarsh ribbonwood communities are mostly confined to undisturbed stream mouths and were otherwise found as scattered individuals along the high spring tide zone. Their extent is restricted by farming activities as they are highly palatable to stock.

Seagrass is an ecologically valuable habitat in the coastal marine area. Seagrass beds can stabilise sediment, influence nutrient cycling, provide a food source for microbes and small invertebrates, and provide habitat for other invertebrates such as crustaceans, shellfish and worms. Seagrass beds also provide foraging ground for shorebirds and feeding and nursery grounds for fish (Jones, 2018).

Kāwhia harbour supports very extensive (Figure 18) and ecologically important seagrass (*Zostera* sp.) beds that extend over 842 hectares (Bouma, 2016) in varying density. These areas far exceed the total area of seagrass in all of the Coromandel Peninsula harbours combined (593ha). In surveys undertaken in 2012, Seagrass beds[52] occurred throughout the mid-harbour flats roughly from Pute Point to Te Aute Point to the east and Matatua Point to Te Motu to Te Maika in the west. Small seagrass patches were also found along the upper reaches of some stream arms (Graeme 2014). Figure 19 shows the distribution of seagrass within the catchment.

Weeds, wild animals and poor agricultural land use were identified by Graeme (2014) as the main threats to estuarine vegetation within Kāwhia Harbour, including the following specific examples:

a. Spartina and saltwater paspalum are the main invasive weed species that are threatening the health and integrity of Waikato estuaries. Small remaining sites and fragments of Spartina; and small populations of saltwater paspalum were identified by Graeme in her 2012 survey. The most concerning saltwater paspalum infestation was located at the head of the Tuapu Creek embayment.
b. Graeme (2014) observed that goats were a particular problem - grazing the understorey of regenerating coastal and lowland forest in the south-western catchments and preventing the regeneration of native forest and riparian margins around the coastal edge. Wild pigs were less common but their presence was noted by the number of 'wallows' and diggings along the inland edges of saltmarsh communities. Canadian geese and wandering stock were also identified as potential vectors for the spread of saltwater paspalum within the harbour.
c. Graeme (2005 and 2014) acknowledged progress had been made to improve poor farming practices in some areas of the harbour, but identified that stock tracking, pugging and defecation along the coastal edge as a common occurrence in Kāwhia Harbour at that time. This damages and destroys estuarine vegetation, exacerbating the spread of weeds around the harbour, pugging the upper tidal zone and accelerating erosion of the coastline. Graeme (2014)

[51] as oioi seems particularly susceptible to damage from pugging and seems to be preferentially grazed
[52] of variable density

concluded that "poor land management[53] within the catchment was causing increased sedimentation and eutrophication of streams and estuaries and degradation of freshwater and estuarine habitats." The following areas of the harbour were identified as being of particular concern:

I. along the peninsula south of the Oparau River (including the Papakura Stream embayment).
II. the coastline near Motukahu Rocks (northern Kauri Stream embayment);
III. areas of the Tapua creek embayment.
IV. the western side and outer eastern side of the Maire Point peninsula.
V. the coastline from the Ohau Stream out towards Nathans Point (Ohaua).

Further education of landowners about the importance of riparian vegetation, was recommended, with greater emphasis on establishing (and planting) riparian margins along the coast and around waterways. Greater protection of kanuka was also recommended as some landowners were observed to be spraying kanuka right to the water's edge (Graeme 2014).

[53] that does not ensure waterways are fenced and vegetated

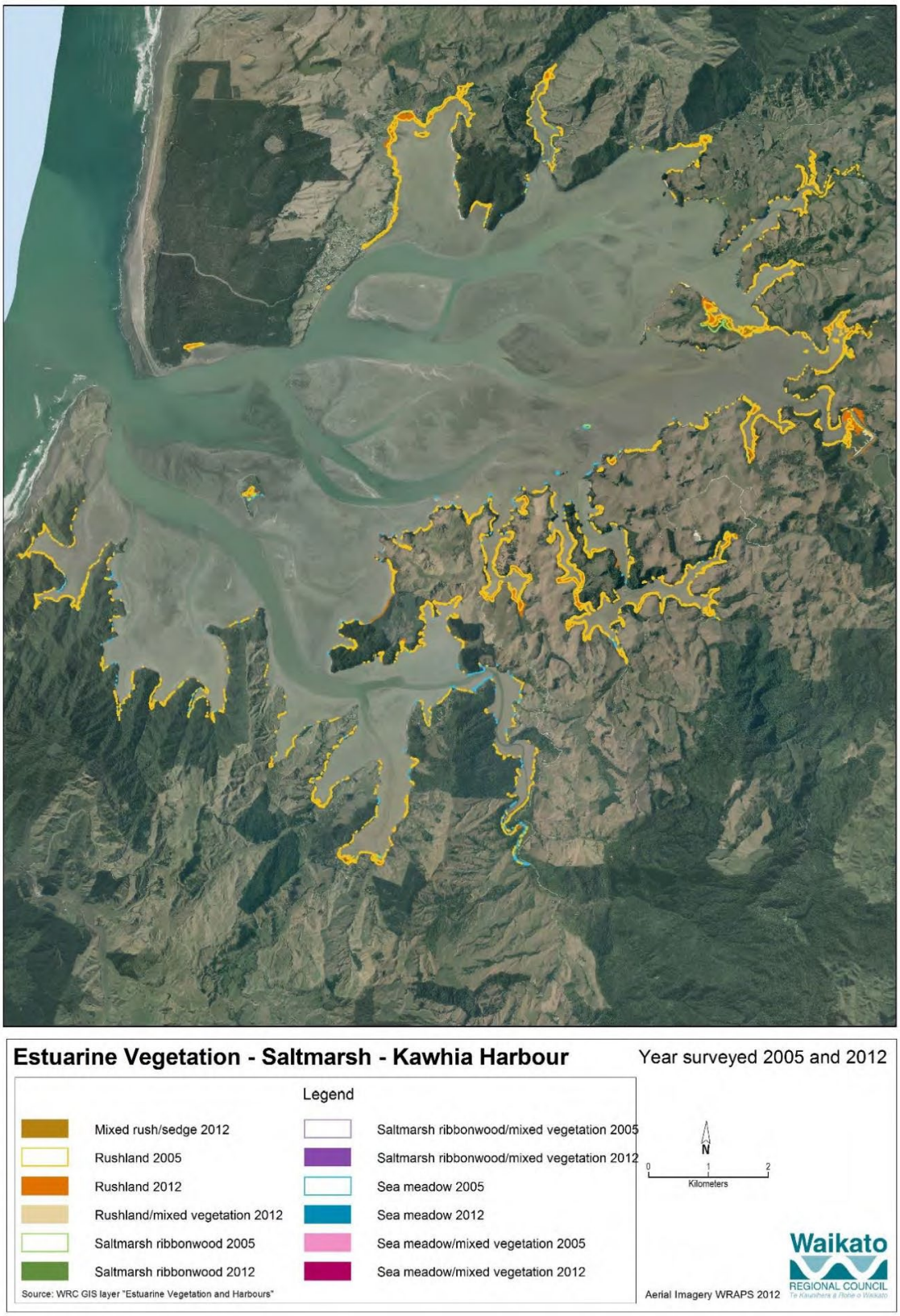


Figure 18. Saltmarsh distribution in Kāwhia Harbour. Source: Bouma (2016).

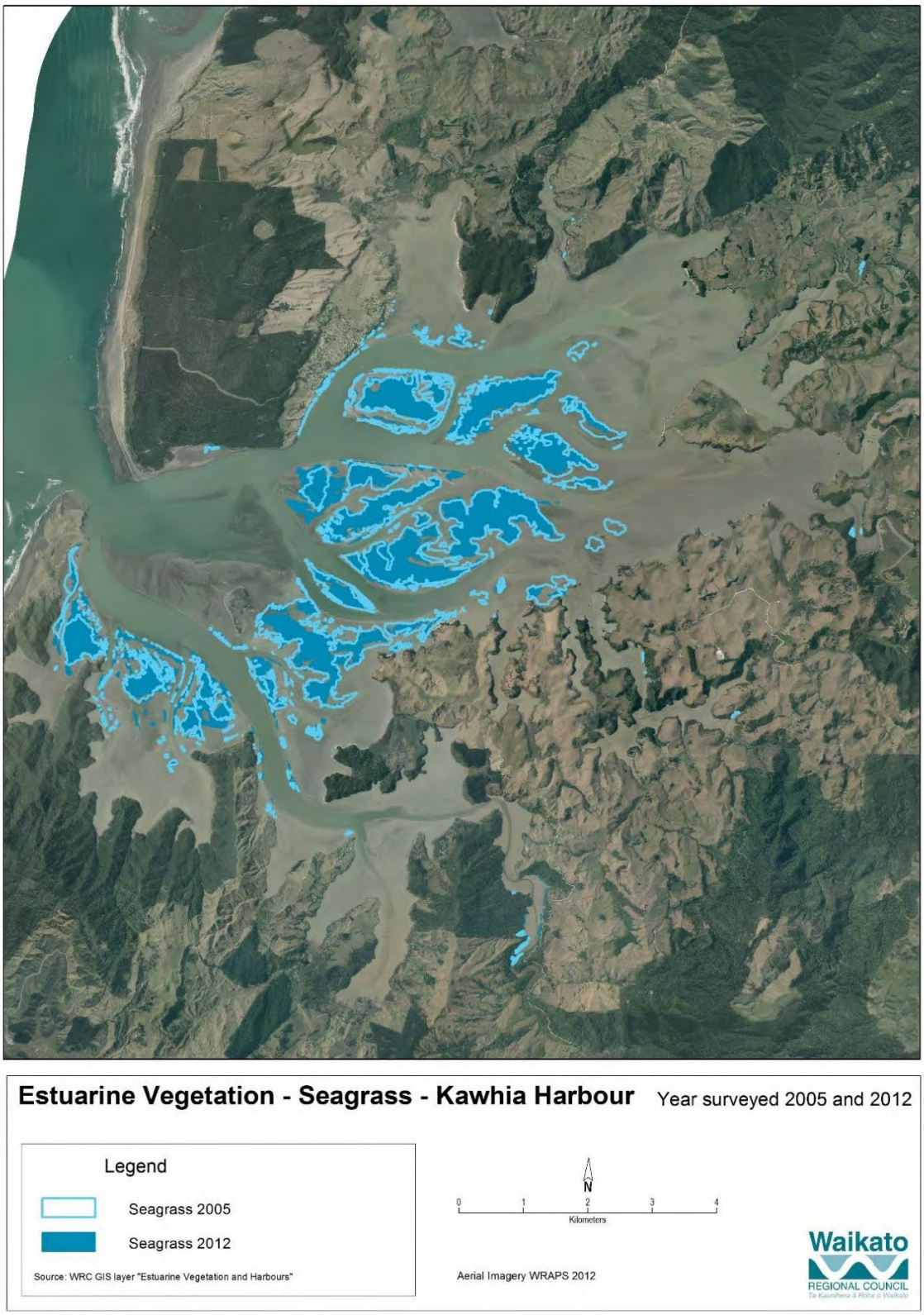


Figure 19. Seagrass distribution in Kāwhia Harbour. Source: Bouma (2016).

6 Biosecurity

6.1 Introduction

Many of New Zealand's indigenous species evolved and once thrived without any native predators. However, introduced pests[54] arrived with humans, and threaten the survival of our indigenous species. Biosecurity helps to prevent or reduce any damage caused by plant or animal pests.

Waikato Regional Council undertakes[55] a range of monitoring, surveillance, enforcement and direct pest control work. Staff also offer advice and information and organise larger scale control programmes.

Pest management is undertaken and prioritised according to a range of considerations, including:

a. Protection of sites with high biodiversity values.
b. Excluding pests from areas they do not yet occur.
c. Rapid eradication of pests that are a high threat but low occurrence.
d. Ongoing maintenance and surveillance to achieve and maintain eradication. This often includes long term commitments from private landowners' and other stakeholders.

In this section, information on a range of pest plants and animals that threaten the Kāwhia Harbour catchment is provided, along with an overview of current management programmes.

6.1.1 Pest Animals

Within the Kāwhia catchment, Waikato Regional Council undertakes possum control within three priority possum control areas on a three yearly basis (see map in Figure 20):

a. Mt Pirongia West buffer
b. Oparau
c. Hauturu-Awaroa

These areas adjoin conservation land on the mountains of Pirongia and Karioi, where the Department of Conservation has a regular aerial possum control programme. Waikato Regional Council's programme extends possum control onto contiguous privately owned farmland to reduce reinvasion and help extend and sustain biodiversity values within and beyond these important conservation areas.

Goats are also a significant issue within the Kāwhia harbour catchment and were identified by Graeme (2014) as a particular issue affecting the regeneration of native forest and riparian buffers around the harbour. Waikato Regional Council currently co-funds the goat control work that DOC undertakes in the Pirongia area. Figure 20 shows the scale of the control areas undertaken by Waikato Regional Council for possums and goats.

[54] Waikato Regional Council uses the term "pest" to refer to an organism specified as a pest in the Regional Pest Management Plan (RPMP). A more general term is "unwanted organism", which his defined in the Biosecurity Act 1993 as any organism that a chief technical officer believes is capable or potentially capable of causing unwanted harm to any natural and/or physical resources or human health. In this report the term "pest" is used loosely to refer to introduced organisms considered a threat to indigenous biodiversity.

[55] Via a network of WRC staff and contractors working across 7 management areas within the region

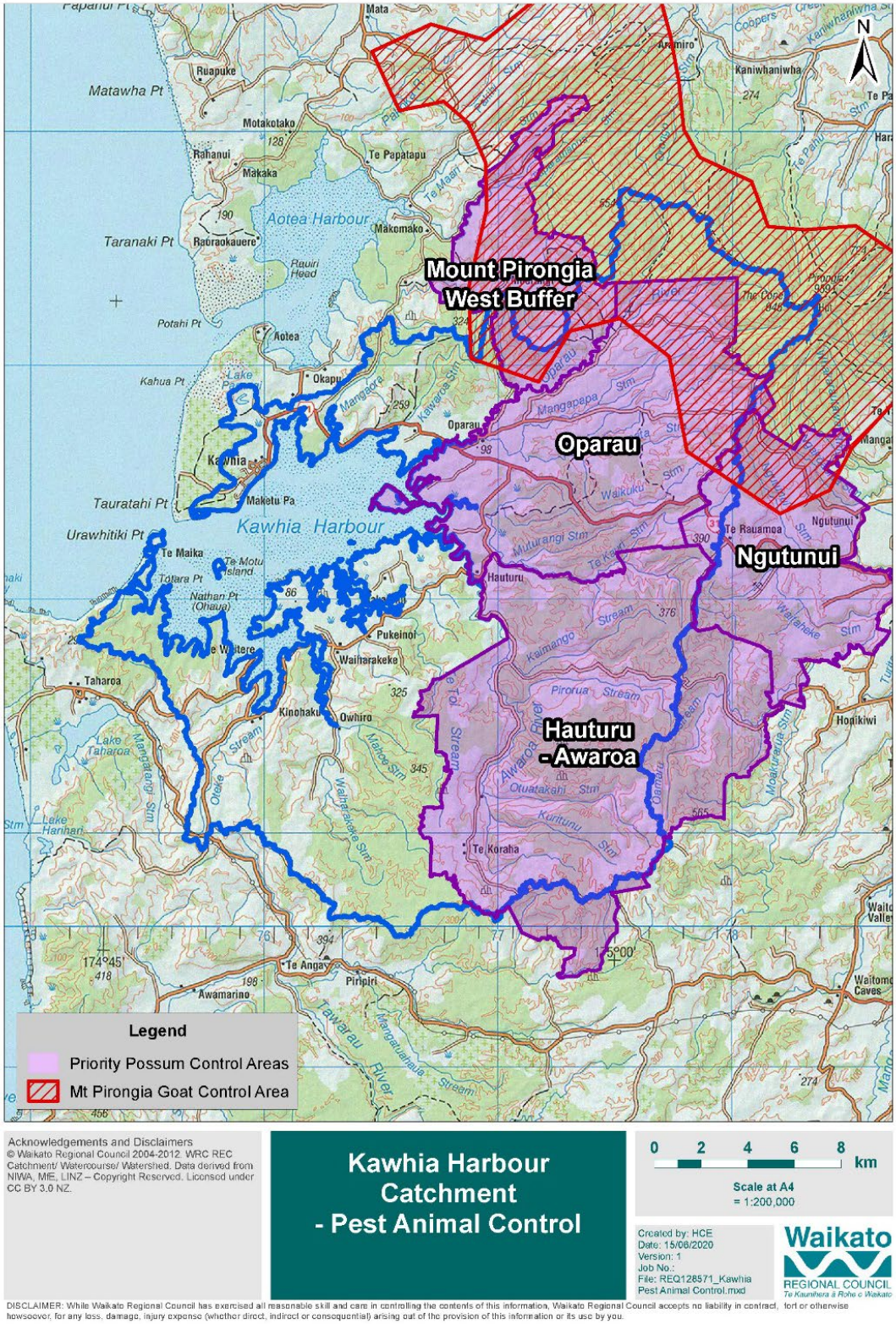


Figure 20. Pest control areas within the Kāwhia Catchment

Swan and Canada geese populations have been identified as being of particular concern for the West Coast harbours as the birds occur in large numbers and are perceived to have a negative impact on the harbours via:

a. Impacts on seagrass beds - via feeding and trampling.
b. deposition of faecal matter-leading to nutrient enrichment, turbidity and microbial contamination.
c. changes to other estuarine vegetation.
d. vectors for disease transmission.
e. distribution of weed propagules.
f. impacts on other birds.

Smith (2019) summarises available information about geese and swans in the West Coast harbours. Moult season surveys in the western Waikato show that swan populations have declined substantially since 1984 to about 5,000 birds (c. one third of the 1984 swan population), and that populations fluctuate but appear to be relatively stable at this level. Approximately 80% of this population now resides in estuarine habitats during moult season, which may be due to the deterioration of lake and wetland habitats within the region. Further surveys are required to understand whether swan numbers are increasing in estuaries, and whether this is related to changes in lake and wetland habitats.

By comparison, surveys show that goose numbers have increased over the past 30 years by a factor of 20, to approximately 10,000 birds. Geese began appearing in estuaries in moult season in 2006 and numbers fluctuate between years but are increasing overall. Approximately 25% of the population was using Aotea, Raglan and Kāwhia estuaries during the 2018 moult season survey. To understand the impacts of goose feeding behaviour in estuaries, diet studies were undertaken by the University of Waikato and Waikato Regional Council. Geese were observed during summer months foraging in seagrass beds utilising several destructive methods, however gut sample analysis indicated that this was not a major part of their diet over winter and spring (Ferries, 2021).

Smith (2019) suggests that these birds could be managed via an integrated approach focused primarily on reducing the adult population. Humane moult season culls applied in conjunction with other methods, such as reproductive control and scaring techniques, are likely to have the greatest impact on population sizes of these birds. Given the mobile nature of these species, management would need to be nationally coordinated. Without effective coordination, vacated habitats would probably quickly be recolonised by remaining populations.

6.1.2 Pest Plant

Alligator weed, yellow flag iris, old mans beard, climbing spindleberry, and boneseed have been identified as key terrestrial weed species within the West Coast Zone.

In April-May 2018, visual weed surveys were undertaken at specific sites around the mouths of Kāwhia, Aotea and Raglan harbours based on known weed surveillance locations and likely areas for debris collection. The target species for this work were sea spurge (*Eupohorbia paralias*), alligator weed (*Alternanthera philoxeroides*) and yellow-flag iris (*Iris pseudocorus*). None of these species were located in these surveys, but spartina, boneseed, evergreen buckthorn, prickly pear cactus, simla, wild ginger, climbing asparagus and bamboo grass were found. Saltwater paspalum, marram, boxthorn, ice plant, agapanthus and yucca have also been located in estuarine and coastal planting areas (Graeme, 2014).

Waikato Regional Council has undertaken the following weed control work within the West Coast zone in recent years (D.Embling, WRC, pers comm):

a. Eradication of alligator weed from the mouth of the Kāwhia harbour.
b. Control and management of yellow flag iris, which is identified as a threat to the harbours.
c. Control and management of old man's beard and climbing spindleberry .
d. Management of boneseed on the cliffs in Raglan.
e. Biocontrol programmes for thistles, woolly nightshade, ragwort, gorse, tradescantia, moth plant, tutsan.
f. Collaborative project with Ministry Primary Industries (MPI) and Department of Conservation (DOC) to eradicate Sea spurge from the west coast.
g. General pest plant surveillance.
h. Managing pest plant threats from outside the catchment to protect the catchment.

Spartina and saltwater paspalum are two key invasive weeds that threaten the health and integrity of Waikato estuaries. Graeme (2005 and 2014) surveyed Kāwhia Harbour and identified the locations of these species which are controlled using the same grass-specific herbicide (refer to map in Figure 21).

Spartina has been the focus of an eradication programme that has been led by the Department of Conservation since 2001 and is subject to an eradication plan. Graeme (2014) observed that the programme made good progress initially but requires ongoing efforts to manage remaining infestations. The eradication plan notes that the Waikato District spartina programme has effectively achieved knockdown and eradication of localised spartina swards/meadows. However, there was a gap in activity from 2012/2013 - 2014/2015 at Kāwhia Harbour, when the programme was in the "mop up" phase of eradication.

The Spartina eradication plan was prepared in 2017/2018 and indicates that there is a high likelihood of eradication from the District within 10-15 years using the (weed-led) criteria for eradication feasibility (Department of Conservation, 2017). This outcome is contingent on several other conditions, including leadership, funding, resourcing and adoption of best practice[56] (A. Styche, DOC, pers. comm.).

Saltwater paspalum (mapped in Figure 21), another weedy grass, was reported as showing an increasing trend in coverage in Kāwhia harbour in 2012 (Graeme, 2014 and Bouma, 2016). Saltwater paspalum is of particular concern in estuaries because of its smothering habit and its wide habitat range[57] which allows it to compete with almost all estuarine vegetation communities except sea grass (Graeme and Kendal 2001). It can grow over vegetation and form dense beds, easily smothering sea meadow, saltmarsh ribbonwood, rushland and even short mangrove communities. At the upstream saltwater limit, saltwater paspalum grows amongst freshwater riparian vegetation and often meets its freshwater invasive relative, Mercer grass (*Paspalum distichum*). Field observations suggest that saltwater paspalum generally excludes burrowing fauna, reduces access to bird feeding and roosting sites, alters fish spawning and feeding grounds, and alters estuarine hydrology by accumulating sediments. Due to its competitiveness and wide-ranging effect on estuarine biodiversity, saltwater paspalum is considered a greater threat than spartina to the ongoing health of the native estuarine communities.

[56] for control, monitoring, surveillance, delimiting, data collection and management
[57] and will colonise open mudflats

Graeme & Kendal (2014) ranked[58] the West Coast estuaries in priority order for control of saltwater paspalum - from Aotea, Kāwhia, Raglan, to Port Waikato. At that time, saltwater paspalum was only beginning to establish and spread in Kāwhia Harbour, but Kāwhia Harbour was considered slightly less vulnerable than the other estuaries. Aotea ranked highest within the region. Since then, there has been a focus on development of control methodologies.

Tiritirimatangi Peninsula and the Awaroa River arm within Kāwhia harbour were identified as important "within estuary" areas for saltwater paspalum control in Kāwhia (Graeme & Kendal 2014).

Figure 21. Spartina and saltwater paspalum distribution in Kāwhia Harbour. Source: Bouma (2016).

[58] Based on the ecological value of the site, the degree of saltwater paspalum infestation, and the site's vulnerability to invasion.

6.1.3 Pathogenic Pests

Kauri dieback disease[59] was discovered in 2009 and is threatening the well-being of kauri within New Zealand. Kauri need protection from kauri dieback disease, which is spread through the movement of contaminated soil, and will cause most infected trees to die prematurely. There is no known cure for kauri dieback, so the best way to protect kauri is by stopping the spread of the disease.

Naturally occurring kauri are found throughout the warmer regions of the upper North Island as far south as Kāwhia, which is the natural southern-most distributional limit Figure 22. The mature stands of kauri within the Kāwhia area are significant in that they represent the southern-most limit of the species in New Zealand and appear to be clear of disease.

Figure 22. Location of Kauri within Kāwhia Harbour Catchment (black outlined circles).

[59] *Phytophthora agathidicida* is a pathogen that causes kauri dieback disease

People, stock and feral animals are the main vectors for spread of kauri dieback (via contaminated soil), so landowners can protect kauri by:

a. fencing out stock.
b. maintaining good hygiene (i.e. clean equipment) to reduce transfer of contaminated soil.
c. managing feral animals.

Practical information[60] is available for rural landowners regarding kauri protection, which establishes guidelines and hygiene standards for activities on land where kauri occur. These guidelines (O'Toole, 2020) focus on reducing the risk of soil transfer and limiting soil and root disturbance around trees. As kauri have a sensitive network of feeder roots through the litter and soil surface, well beyond the canopy drip line, fences must be placed beyond the kauri root zone. The root zone is defined as a distance three times the radius of the outermost canopy dripline.

[60] Protecting Kauri: A rural landowners guide - Guide_protect-kauri-rural-property.pdf (kauriprotection.co.nz)

7 Hazards

7.1 Introduction

New Zealand consists of a range of geographical and geological features that contribute to the occurrence of natural hazards. The country lies across two tectonic plates that are pushing against each other, creating the many mountains and volcanos that occur down the centre of the country as well as frequent earthquake events. The mountains also intensify rain events and flooding is generally the most frequent natural disaster that occurs in New Zealand.

Natural hazard risk in the Waikato region is increasing, mainly because development is still occurring in hazard prone areas. The coastal environment is one of the most active environments in the region and is subject to regular and sometimes instantaneous changes due to erosion and inundation. In the coastal environment, natural hazards may include coastal erosion, sand drift, wind erosion, coastal flooding, changes in sea-level, tsunami, storms and cyclones.

This section outlines the Kāwhia catchment's vulnerability to natural hazards as well as identification of known and potential natural hazards that the catchment may be susceptible to.

7.2 Vulnerability to natural hazards

A report titled Natural Hazard Risk Assessment - Ōtorohanga District (Ryan, 2009) described the geological features in the Ōtorohanga District. The features that are relevant to the Kāwhia catchment are:

a. Much of the lower lying geological units include a significant portion of material derived from volcanic fallout.
b. Much of the coastal geological units consist of highly mobile marine sediments that result in a dynamic shoreline.
c. An interesting geological feature in the Ōtorohanga District is the presence of karst features. Karst includes a variety of distinctive and often spectacular surface and underground features formed predominantly by the dissolving action of water through limestone bedrock. The presence of karst in the Ōtorohanga District is particularly relevant to the management of natural hazards, as the creation of underground karst formations often (eventually) results in localised subsidence.

The coastline around the harbour entrances is likely to be dynamic due to the presence of mobile material (e.g. sand, gravel and mud) and coastal features such as sand spits and bars that are sensitive to natural fluctuations in the coastal environment. This dynamic environment also extends into the lower harbours, where there is evidence of shoreline fluctuations (Ryan, 2009).

Ryan (2009) also identified two hazards, coastal inundation and cliff instability, as not being significant but there is the potential that these two hazards could escalate through the development of low-lying land surrounding the harbour.

Tsunamis are a threat to people and property in coastal and low-lying estuarine areas. The waves travel quickly, rapidly flooding and damaging coastal communities, picking up debris as they go (Ryan, 2009). The coastal areas of the Kāwhia catchment have less risk of tsunami due to the sheltering effect of New Zealand from the most likely sources.

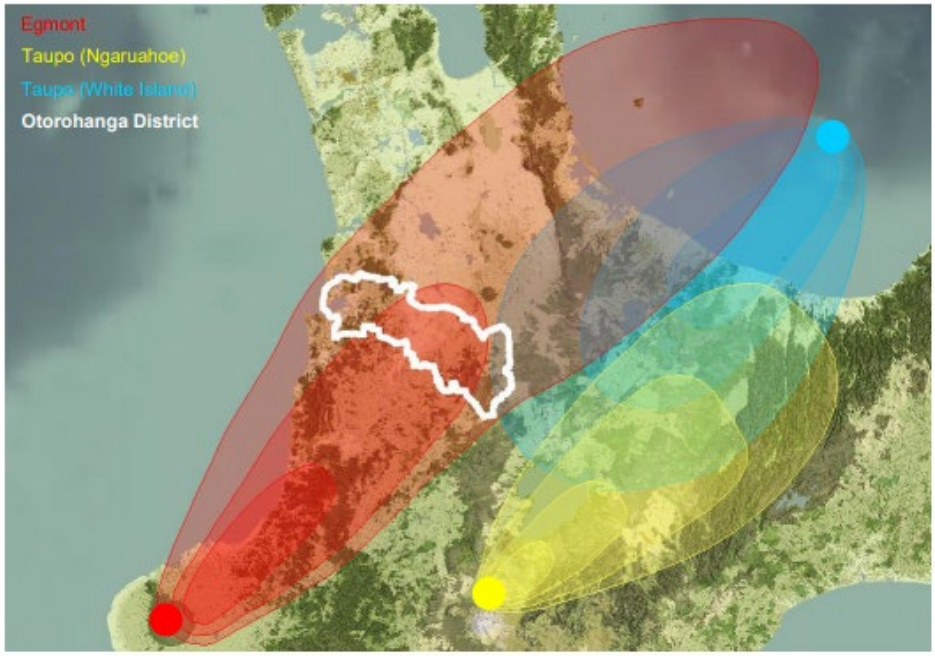


Figure 23. Most probable volcanic fallout across the Waikato Region (Ryan, 2009)

Although none of the identified volcanic centres are located within the Ōtorohanga District, there is the potential for the Kāwhia catchment area to be affected by fallout following an eruption (as is evidenced by the presence of ash in much of the under lying geology). Figure 23 shows that this fallout is most likely to originate from the Egmont volcanic centre (Ryan, 2009).

7.3 Identifying natural hazards

Natural hazards can cause disruption, damage properties and take lives. To improve access to hazard information, and help the public, local authorities and others to make informed decisions, Waikato Regional Council has developed a Waikato Regional Hazards Portal (Figure 24)[61]. The Portal contains all available (suitably robust) spatial hazard information that is held by Waikato Regional Council, as well as some data from other organisations. For the Kāwhia catchment, the portal identifies known and potential hazards relating to:

a. Flooding.
b. Coastal hazards.
c. Coastal inundation.
d. Earthquakes and landslides.

As a result of climate change West Coast harbour catchments will be subject to more of the high intensity rainfall and storm events that trigger short-term erosion and subsequently increase sedimentation in rivers, streams, and the coastal environment. The predicted influence of these hazards is displayed in the Waikato Regional Hazards Portal.

[61] www.waikatoregion.govt.nz/regional-hazards-portal

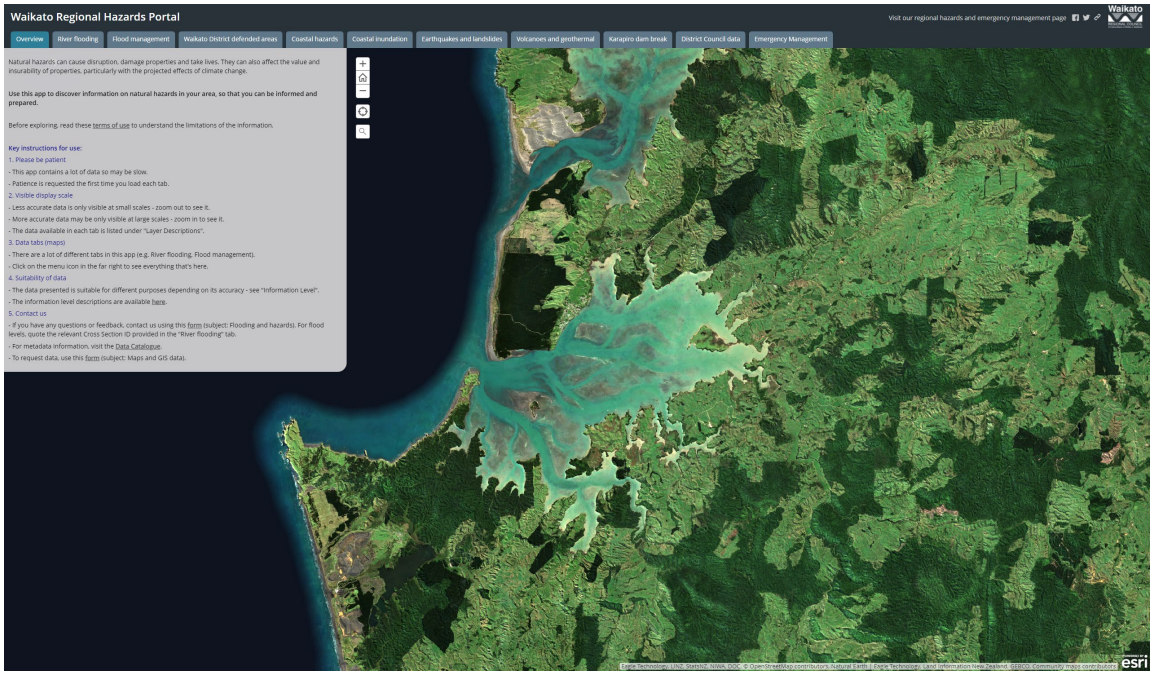


Figure 24. Screenshot of the Waikato Regional Council Hazards Portal. Source: WRC Hazard Portal.

8 Climate Change

8.1 Introduction

Climate change is predicted to affect rivers and streams through changes to base flows, flow patterns[62], increased flooding, increased water temperatures, declining water quality; increased erosion and sediment transport; increased salinity of river mouths (due to sea level rise); reduced freshwater habitats and disruption of migrations. Human responses to climate change are likely to add further pressure with increased demand for water abstraction, dam and irrigation schemes, and engineering for flood prevention to protect human life, infrastructure and the economy. These impacts are likely to vary amongst catchments depending on flow source so are difficult to predict with confidence.

As greenhouse gases increase in our atmosphere, New Zealand is experiencing the impact of a changing climate. The latest Ministry for the Environment report gave an increase in the average annual temperature by 1.13 degrees Celsius from 1909 to 2019 and we are seeing sea levels rise, changes in drought and extreme rainfall (Ministry for the Environment, 2021).

Water temperature and acidity of coastal waters are predicted to increase with climate change, which may change the suitability of coastal waters for marine species and make coastal waters more susceptible to undesirable consequences, such as algal blooms.

8.2 Climate change projections for the Waikato region

The Ministry for the Environment (MfE) has provided an overview of how the climate in the Waikato region is likely to change into the future and what implications this has for the region.[63]

These predictions are not certain. As explained by the MfE, projections of climate change depend on future greenhouse gas emissions, which are uncertain. Predictions are based on four main global emissions scenarios ranging from low to high greenhouse gas concentrations. These were used to calculate regional projections for a transition from a low emission to a high emissions future. The projected changes are calculated for 2031-2050 (referred to as 2040) and 2081-2100 (2090) compared to the climate of 1986-2005 (1995).

Climate change projections for the Waikato region are summarised in Table 10. In summary, the changes likely to be experienced in the Kāwhia catchment over the coming 20 to 70 years are:

a. Increased temperatures, including:
    I. increased daily average temperatures.
    II. increased days with high temperatures (over 25 ˚C); and
    III. less frosts.
b. Increased winter rainfall and reduced spring rainfall but there will be local variation and projections are uncertain.
c. Potential increase in westerly wind flow during winter, and north-easterly wind flow during summer.
d. Some increase in storm intensity, local wind extremes and thunderstorms. Ex-tropical cyclones will likely be stronger and cause more damage as a result of heavy rain and strong winds.

[62] and altered frequency and timing of ecologically important flow events

[63] www.mfe.govt.nz/climate-change/likely-impacts-of-climate-change/how-could-climate-change-affect-my-region/waikato

e. Over the 20th century there has been an average rise in relative mean sea level of 1.7 mm per year. Further rise is expected in the future.

Table 10. Climate change projections for the Waikato region provided by the Ministry for the Environment. Source: www.mfe.govt.nz/climate-change/likely-impacts-of-climate-change/how-could-climate-change-affect-my-region/waikato.

	**Temperature**
Compared to 1995, temperatures are likely to be 0.7˚C to 1.1˚C warmer by 2040 and 0.7˚C to 3.1˚C warmer by 2090. By 2090, the Waikato is projected to have from 10 to 60 extra days per year where maximum temperatures exceed 25˚C. The number of frosts could decrease by around 5 to 13 days per year in Waikato, with frosts becoming rare in the Coromandel.	
	**Rainfall**
Rainfall will vary locally within the region. The largest changes will be for particular seasons rather than annually. Winter rainfall in Ruakura is projected to increase by 4 to 8 per cent by 2090. In Taupo, winter rainfall is projected to increase by 4 to 7 per cent by 2090. Spring rainfall is projected to decrease by up to 6 per cent in both locations. According to the most recent projections, the Waikato is not expected to experience a significant change in the frequency of extreme rain days as a result of climate change.	
	**Wind**
The frequency of extremely windy days is likely to decrease by 2 to 3 per cent. There may be an increase in westerly wind flow during winter, and north-easterly wind flow during summer.	
	**Storms**
Future changes in the frequency of storms are likely to be small compared to natural inter-annual variability. Some increase in storm intensity, local wind extremes and thunderstorms is likely to occur. The frequency of ex-tropical cyclones is projected to either decrease or remain unchanged over the 21st century; however, the ex-tropical cyclones will likely be stronger and cause more damage as a result of heavy rain and strong winds.	
	**Sea-level rise**
New Zealand tide records show an average rise in relative mean sea level of 1.7 mm per year over the 20th century. Globally, the rate of rise has increased, and further rise is expected in the future. The Ministry for the Environment provides guidance on coastal hazards and climate change, including recommendations for sea level rise.	

8.3 Likely effects of climate change in the Kāwhia catchment

The most likely climate-induced changes identified for the Kāwhia community are droughts, sea level rise and river flooding events. The Kāwhia community are likely to experience similar impacts to those identified in a study in Manaia - Examining community risk, vulnerability and endurance at Manaia Settlement, Hauraki-Waikato, Aotearoa-New Zealand (King et al, 2012):

a. Increased coastal erosion and destabilisation of coastal slopes from rising sea-levels and storms.
b. Increased risk of coastal flooding from rising sea-levels and extreme weather events.
c. Permanent inundation of low-lying coastal areas including saltwater intrusion (salinization) into fresh water resources and farm paddocks.
d. Structural damage to privately owned buildings and key infrastructure such as local roads from higher water levels and periodic storms.
e. Degradation of sacred places and sites resulting in loss of identity and whakapapa.
f. Adverse impacts on ecology from erosion, sedimentation and pollution from destruction of septic tanks and sewer lines.
g. Danger of injury and loss of life in the case of extreme flooding events; and
h. Rising costs surrounding the maintenance, repair and re-design of whānau homes and vital infrastructures to cope with such changes.

9 Prioritisation of conservation and restoration activities

Prioritisation of restoration locations and activities is necessary to ensure resources are utilised in the most effective way. In other parts of the region a modelling approach has been used to prioritise catchments and sub-catchments and to guide catchment management activities.

This section provides an overview of the prioritisation processes that have been used by Waikato Regional Council in the Kāwhia catchment.

9.1 Sub-catchment prioritisation process for the West Coast harbour catchments

To support the implementation of the West Coast Zone Plan and help direct resources to activities and areas of greatest environmental and community benefit within the harbours, Singleton (2018) undertook a sub-catchment prioritisation process for the West Coast harbour catchments that involved:

a. Dividing the Kāwhia catchment into seven sub-catchments (Kāwhia, Mangaroa, Oparau, Te Kauri, Awaroa, Te Toi, and Waiharakeke).
b. Identifying features, issues and uses of each sub-catchment using a range of information[64].
c. Scoring each sub-catchment (and its downstream harbour area) on the basis of a several categories including:
    I. Land instability (poor vegetation protection, sediment and erosion risk) - scored as the % of sub-catchment with moderate or higher risk.
    II. Water quality risks (E. coli, N, P, stream bank erosion and stocking risk) - scored as the % of sub-catchment with moderate or higher risk.
    III. Biodiversity values of the land (priority streams, priority areas on private land, SNAs) - scored as the km of high-risk stream, % of priority native cover on private land, and % of vegetation that is regionally, nationally or internationally significant.
    IV. Importance of harbour features (presence of salt marsh or seagrass, shellfish beds, coastal flushing) - scoring based on the relative abundance of shellfish or habitat near the catchment discharge.
    V. Relative importance for community activities (tourism and visitors, water based commercial activities, swimming, food gathering, schools and marae, care groups) - scoring based on the relative use of the sub-catchment for a range of community activities.

Using this process, Singleton (2018) sought to identify the sub-catchments with the highest land and water quality risks, the most important biodiversity values, and the most community use and engagement. In this way, he intended for Waikato Regional Council to maximise the biodiversity and community benefits from land and water improvements.

Table 11. Total category scores and priority ranking of Kawhia harbour subcatchments (Singleton 2018).

Sub-catchment	Land Instability Risk Score	Water Quality Risk Score	Biodiversity Score	Harbour Score	Community Score	TOTAL Score	Rank within Kāwhia Harbour
Kāwhia	24	1	55	9	40	129	6

[64] including reports, plans and planning documents, and conversations with local staff

Mangaroa	78	17	42	20	15	172	4
Oparau	60	59	51	18	4	192	3=
Te Kauri	66	62	52	18	5	203	2
Awaroa	89	46	76	18	14	243	1
Te Toi	49	25	53	25	9	161	5
Waiharakeke	62	34	64	20	12	192	3=

Table 11 shows the final category scores and overall priority rankings for each of the sub-catchments of Kāwhia Harbour derived by Singleton (2018).

The Awaroa sub-catchment was ranked highest when all categories were combined and was the highest ranked for land instability risk and biodiversity. Te Kauri was ranked second highest and had the highest score for water quality risk. Oparau and Waiharakeke were ranked third equal.

9.2 Waikato Regional Prioritisation Framework

In 2013 the Waikato Regional Council Land and Water Forum identified a need to better prioritise incentivised catchment management works regionally and within Zones. As a result, a prioritisation framework was developed internally and used to support the preparation and implementation of the Waipā Catchment Plan (WRC, 2014). Following this the Waikato Prioritisation Framework (WPF) was developed for the whole of region in 2015 (Hill and Borman, 2016). A 2018 revision supported the identification of priority locations and mitigations for the Waikato and Waipā River Restoration Strategy (Neilson et al., 2018). Further revisions and updates have been completed periodically, with the most recent revision undertaken in 2021 (Norris et al., 2021).

The WPF is a spatial framework that utilises spatial model data from multiple sources and applies geospatial techniques for determining priorities based on risk. It provides a decision support tool for prioritisation across catchments, identifying locations with the greatest potential for water quality improvement, and with the likely greatest cost benefit in implementing soil conservation mitigations (Norris et al., 2021). Although the outputs of the project were intended primarily to be used by the Waikato Regional Council, they can also be of benefit to mana whenua, Co-governance partners, and land managers, funding agencies and communities within the wider Waikato region (Hill and Borman, 2016).

As part of the 2021 revision of the WPF, a detailed assessment of risks, mitigations, costs and potential outcomes was undertaken for the West Coast Zone, including for the harbour catchments. The outcomes of this assessment have been used to refine and confirm priority Waikato Regional Council sub catchments for management of soil conservation and erosion in the Kāwhia harbour catchment.

The results of the WPF identify the Te Kauri sub-catchment as the highest priority for management for both soil conservation and nutrient risk (nitrogen and phosphorus). The Awaroa sub-catchment was identified as the second highest priority for soil conservation. This aligns with the catchments identified by Singleton (2018) as high risk for these factors.

Table 12. Summarised Waikato Regional Prioritisation Project mitigation estimates for Kāwhia harbour catchment (Norris et al., 2021).

	Kāwhia
Total area of combined sub catchments (ha)	45,230ha
Mean sub catchment area (ha)	6,461ha
Ranking for soil conservation risk	Te Kauri Awaroa

	Oparau Mangaroa Te Toi Waiharakeke Kāwhia
Ranking for water quality risk	Te Kauri Oparau Te Toi Awaroa Mangaroa Waiharakeke Kāwhia
Hill slope mitigation costs ($)	$19,523,598
Riparian mitigation costs ($)	$10,215,771
Total mitigation costs ($)	**$29,739,369**
Mitigation sediment reductions (%)	50%
Mitigation nitrogen reductions (%)	17%
Mitigation phosphorus reductions (%)	27%
Mitigation E. coli reductions (%)	24%

In terms of potential outcomes for the Kāwhia harbour catchment, the WPF model estimated relative reductions in sediment and other contaminant generation before and after a range of mitigations for hill slope and streambank protection. It also enabled an estimate of costs to achieve these reductions. A summary of mitigation costs and estimated reductions for the Kāwhia catchment is displayed in Table 12. This assumes management actions including retirement and revegetation of very steep land, stabilising other steep areas with open spaced pole planting, and undertaking riparian fencing and planting (Norris et al., 2021). The total cost of this work as of 2021 was estimated to be approximately $29.7m. Modelling predicted that if this work was undertaken it would achieve a 50% reduction in sediment to waterways and a 24% reduction in E. coli.

A detailed summary of the WPF and results for the West Coast can be found in Norris et al., (2021). This work has informed the priorities and actions identified in the Kāwhia Catchment Management Plan, scheduled for publication in 2024. The priorities have also been incorporated into work programmes across the rest of the West Coast Zone from 2023/24 and an update of the West Coast Zone Plan (*in prep*).

9.3 Catchment works

Waikato Regional Council has an active programme of catchment works within the Kāwhia catchment, working with landowners, community groups and other stakeholders. The map (Figure 25) shows the properties (shaded in yellow) where WRC and landowners have previously entered into an agreement regarding funding and support, and maintenance for catchment management projects. Funding priorities to date have been driven by priority catchments, sites and actions identified within the West Coast Zone Plan (Addenbrooke et al., 2016).

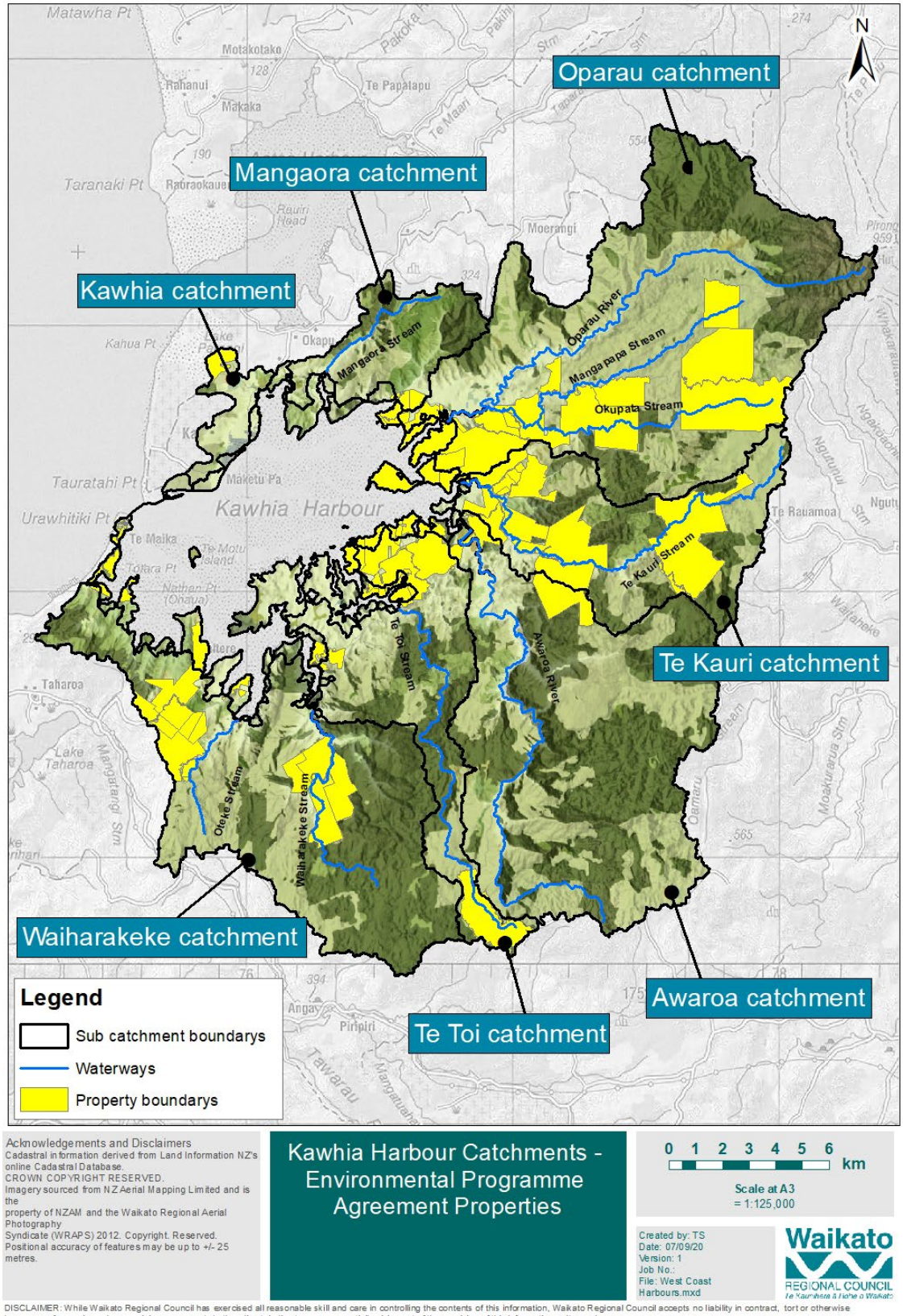


Figure 25. Extent of properties that have Environmental Programme Agreements with the Waikato Regional Council within the Kāwhia Catchment

9.4 Coastcare

Coastcare Waikato is a community programme that aims to protect and restore coastal environments throughout the Waikato Region. It is a collaborative programme supported by Waikato Regional Council, Waikato District Council, Hauraki District Council, Thames-Coromandel District Council and the Department of Conservation. Together these organisations work with coastal community groups, iwi and landowners (Figure 26) to help them restore beaches, coastal wetlands and coastal forests. This is intended to protect and restore biodiversity, ecosystem services, natural character, cultural values, amenity and natural hazard mitigation values. There is an active Coastcare programme in Kāwhia Harbour.

The Coastcare Waikato Kāwhia group has developed a Kāwhia Coastal Restoration and Management Plan 2018-2030 and has a vision: *The Kāwhia community creates a restored landscape with abundant biodiversity and healthy kaimoana*. The Kāwhia group has recently been involved in a project exploring practical options to transition failing exotic forest buffers to resilient permanent indigenous coastal forest buffers. A planting trial site at Kawhia has been completed in collaboration with forestry managers, iwi, landowners, councils and communities. The key objective is to determine a suite of cost-effective methods for conversion of the exotic dominated coastal buffer to natives. This is likely to comprise a number of approaches where the aim is to assist natural succession wherever possible.

Figure 26. Community planting day at Kāwhia (Source: Coastcare Waikato - Kāwhia).

References

Addenbrooke J, McKenzie A, Lawrence L 2016. West Coast Zone Plan : Te Mahere o te Rohe Taihauāuru. Waikato Regional Council Technical Report 2016/08. Hamilton, Waikato Regional Council.

Brandon A, de Lange P, Townsend A 2004. Threatened plants of Waikato Conservancy. Wellington, Department of Conservation.

Boffa Miskell 2016. Natural Character study of the Waikato coastal environment. Waikato Regional Council Technical Repot 2016/05. Hamilton, Waikato Regional Council.

Bouma S 2016. Marine biodiversity stocktake of the Waikato Region 2015. Waikato Regional Council Technical Report 2015/48. Hamilton, Waikato Regional Council.

Burton T, Smith B 2015. Investigation of submerged plants and invertebrates in Lake Koraha. NIWA Client Report HAM2015-056 prepared for DOC and WRC. Hamilton, National Institute of Water and Atmospheric Research (NIWA).

Cromarty P, Scott D 1996. A directory of wetlands in New Zealand. Wellington, Department of Conservation.

Dahm J 2021. Te Maika : coastal hazards and management recommendations. Internal report for Waikato Regional Council and Te Maika Trust.

David B, Bourke C, Hamer M, Scothern S, Pingram M, Lake M 2016. Incorporating fish monitoring into the Waikato Regional Councils' Regional Ecological Monitoring of Streams (REMS) - preliminary results for wadeable streams 2009-2015. Waikato Regional Council Technical Report 2016/29. Hamilton, Waikato Regional Council.

Dean-Speirs T, Neilson K 2014. Waikato Regional Shallow Lakes Management Plan (Volumes 1 &2) Waikato Regional Council Technical Reports 2014/58 & 2014/59. Hamilton, Waikato Regional Council.

Department of Conservation 2017. Spartina Eradication Plan: Hauraki, Waikato and Whitianga District Offices for 2017/18 - 2032/33. Wellington, Department of Conservation.

Dowding J, Moore S 2006. Habitat networks of indigenous shorebirds in New Zealand. Science for Conservation 261. Wellington, Department of Conservation.

Dowding JE 2019. Sites of importance to shorebirds and seabirds in the Waikato region. Waikato Regional Council Technical Report 2019/20. Hamilton, Waikato Regional Council.

Environment Waikato 2009. Shore Futures: Preferred Futures Report: a collective vision for healthy harbours and communities in the Kawhia and Aotea catchments. Hamilton, Waikato Regional Council (Environment Waikato).

Ferries M 2021. The use of seagrass (Zostera muelleri) habitat by Canada geese (Branta canadensis) in Waikato estuaries. Unpublished MSc thesis. Hamilton, University of Waikato.

Golder Associates 2007. West Coast Natural Character and Landscape Assessment (Kawhia and Aotea Catchments). Report Number ENVWAWKT002. Commissioned by Environment Waikato. Auckland, Golder Associates.

Graeme M 2005. Estuarine vegetation survey: Kāwhia Harbour. Environment Waikato Technical Report 2005/42. Hamilton, Waikato Regional Council (Environment Waikato).

Graeme M 2014. Estuarine vegetation survey (2012): Kāwhia Harbour. Waikato Regional Council Technical Report 2014/16. Hamilton, Waikato Regional Council.

Graeme M, Kendal H 2001. Saltwater Paspalum (Paspalum vaginatum) - a weed review. Report prepared for Environment Waikato. Coromandel, Natural Solutions - Marine & Terrestrial Ecologists Ltd.

Graeme M, Kendal H 2014. Ecological prioritisation for saltwater paspalum control in the Waikato region. Waikato Regional Council Internal Report 2015/46. http://www/pdf/is2015/is15-46.pdfHamilton, Waikato Regional Council.

Grainger N, Collier K J, Hitchmough R, Harding JS, Smith BJ, Sutherland DL 2014. Conservation status of New Zealand freshwater invertebrates, 2013. New Zealand Threat Classification Series 8. Wellington, Department of Conservation.

Grant C, Hay B 2003. A review of issues related to depletion of populations of selected infaunal bivalve species in the Hauraki Gulf Marine Park. Unpublished report prepared for the Hauraki Gulf Forum. AquaBio Consultants Ltd.

Greer D, Atkin E, Mead S, Haggitt T, O'Neill S 2016. Mapping residence times in west coast estuaries of the Waikato region. Waikato Regional Council Technical Report 2016/19. Hamilton, Waikato Regional Council.

Harding M 1997. Waikato Protection Strategy: a report to the Forest Heritage Fund Committee. Wellington, Forest Heritage Fund.

Henry J 2020. Community Survey Summary - Whāingaroa (Raglan), Aotea and Kāwhia Harbour Catchments. March 2020. (WRC document reference 15967310). Hamilton, Waikato Regional Council.

Hill R, Borman D, Neilson K, Leathwick J 2015. Waikato Regional Prioritisation Project: A spatial framework for prioritising soil conservation, water quality and biodiversity (phase1). Waikato Regional Council Technical Report 2015/19. Hamilton, Waikato Regional Council.

Hill R, Borman D 2016. Waikato Regional Prioritisation Project: Phase 2 overview. Waikato Regional Council Internal Series 2016/22. Hamilton, Waikato Regional Council.

Hillock K, Rohan M 2011. Intertidal benthic habitats of Kāwhia and Aotea harbours. DOC Research and Development Series 327. Wellington, Department of Conservation.

Hunt S 2021. Optimisation of the Waikato Regional Council tide gauge network. Waikato Regional Council Technical Report 2021/25. Hamilton, Waikato Regional Council.

Jones H, Kimberley M, Hill R, Borman D 2016. Riparian characteristics of pastoral waterways in the Waikato region, 2002-2012. Waikato Regional Council Technical Report 2015/49. Hamilton, Waikato Regional Council.

Jones H 2018. Internal WRC memo - Subtidal seagrass in the Waikato region April 2018. (WRC document reference 12339117). Hamilton, Waikato Regional Council.

Kamke J 2021. State of coastal water quality for the west coast of the Waikato region 1994-2021. Waikato Regional Council Internal Series 2021/17. Hamilton, Waikato Regional Council.

Kelly J, Fenton T 2012. Planning for improved sustainable land management through integrated catchment management. Collation of existing information for the West Coast Zone. Unpublished report from Alchemists Ltd. for Waikato Regional Council. Hamilton, Alchemists Ltd.

King D, Dalton W, Bind J, Srinivasan M, Duncan M, Skipper A, Ashford-Hosking D, Williams B, Renata H, Baker M 2012. Coastal adaptation to climate variability and change : examining community risk, vulnerability and endurance at Manaia Settlement, Hauraki-Waikato, Aotearoa-New Zealand. NIWA Report No: AKL2012-029. Auckland, National Institute of Water and Atmospheric Research (NIWA).

Leathwick J, Clarkson B, Whaley P 1995. Vegetation of the Waikato Region: current and historical perspectives. Landcare Research Contract Report LC9596/022. Hamilton, Manaaki Whenua - Landcare Research.

Leathwick J, Julian K 2009. Identification of high value rivers and streams in the Waikato Region: final report. Environment Waikato Technical Report 2009/05. Hamilton, Waikato Regional Council (Environment Waikato).

Lynn I, Manderson A, Page M, Harmsworth G, Eyles G, Douglas G, Mackay A 2009. Land use capability survey handbook: a New Zealand handbook for the classification of land. Hamilton, Agresearch Ltd.

Mead S, Moores A 2004. Estuary sedimentation: a review of estuarine sedimentation in the Waikato Region. Waikato Regional Council Technical Report Series 2005/13. Hamilton, Waikato Regional Council.

Melchior M, Williams A, Hamer M, Pingram M, Collier K 2023. The state of freshwater mussels (Kākahi, Kāeo) in Waikato wadeable streams. Waikato Regional Council Technical Report 2022/01. Hamilton, Waikato Regional Council.

Ministry for the Environment 2021. He kupu ārahi mō te aromatawai tūraru huringa āhuarangi ā-rohe / A guide to local climate change risk assessments. Wellington, Ministry for the Environment.

Ministry for the Environment and Stats NZ 2021. Our land 2021. New Zealand's environmental reporting series/ME 1555. Wellington, Ministry for the Environment.

National Institute of Water and Atmospheric Research (NIWA) 2015. Lake Koraha: A hidden gem in the Waikato. NIWA Freshwater Update no. 66, July. https://niwa.co.nz/lakes/freshwater-update/freshwater-update-66-july-2015/lake-koraha-hidden-gem-waikato [accessed January 2022]

Neilson K, Hodges M, Williams J, Bradly N 2018. Waikato and Waipā River restoration strategy - Te Rautiki Tāmata i ngā Awa o Waikato me Waipā. Waikato Regional Council, DairyNZ and Waikato River Authority. Hamilton, Waikato Regional Council.

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. Hamilton, Waikato Regional Council.

Norris M, Borman D, Hill R 2021. Waikato Prioritisation Framework and its use for soil conservation : development and methods. Waikato Regional Council Technical Report 2021/06. Hamilton, Waikato Regional Council.

O'Toole K, Parker K 2020. Protecting kauri: Preventing the spread of kauri dieback on rural properties. Wellington, Ministry for Primary Industries. Guide_protect-kauri-rural-property.pdf (kauriprotection.co.nz)

Ōtorohanga District Council 2021. Water, wastewater and stormwater. https://www.otodc.govt.nz/council-services/water-wastewater-and-stormwater [accessed January 2022]

Pingram M, Collier K, Hamer M, David B, Caitlin A, Smith J 2019. Improving region-wide ecological condition of wadeable streams: Risk analyses highlight key stressors for policy and management. Environmental Science & Policy 92: 171-180.

Ratana K, Herangi N, Te Huia S, Tane W 2017. Prioritising wetland restoration efforts based on Mātauranga-ā-Hapū in the Kāwhia Rohe. NIWA Client Report 2017124HN. https://waimaori.maori.nz/wp-content/uploads/2019/05/Wetland_Restoration.pdf [accessed January 2022]

Ratana K, Herangi N, Murray T 2019. Me pēhea te whakarauora i ngā repo o Ngāti Maniapoto? How do we go about restoring the wetlands of Ngāti Maniapoto? New Zealand Journal of Ecology 43(3): 3391.

Robertson HA, Baird K, Dowding JE, Elliott GP, Hitchmough RA, Miskelly CM, McArthur N,O'Donnell CFJ, Sagar PM, Scofield RP, Taylor GA 2017. Conservation status of New Zealand birds, 2016. New Zealand Threat Classification Series 19. Department of Conservation, Wellington. https://www.doc.govt.nz/globalassets/documents/science-and-technical/nztcs19entire.pdf [accessed January 2022]

Rumsby A 2009. Trace elements in the sediment of Waikato West Coast Estuaries. Waikato Regional Council Technical Report 2009/08. Hamilton, Waikato Regional Council.

Ryan G 2009. Natural hazard risk assessment Ōtorohanga District. Waikato Regional Council Technical Report 2009/34. Hamilton, Waikato Regional Council.

Salu A 2021. Regional rivers water quality monitoring programme data report 2020. Waikato Regional Council Technical Report 2021/19. Hamilton, Waikato Regional Council.

Singers N, Rogers M 2014. A classification of New Zealand's terrestrial ecosystems. Science for Conservation 325. Wellington, Department of Conservation.

Singleton P 2018. Priority West Coast harbour catchments : sub-catchment prioritisation : report. Report from Natural Knowledge Ltd for Waikato Regional Council.

Smith B 2019. Use of West Coast Waikato estuaries by Canada geese and black swans. Waikato Regional Council Technical Report 2019/16. Hamilton, Waikato Regional Council.

Tonkin and Taylor Ltd. 2008. West Coast Hazard Project. Waikato Regional Council Technical Report 2008/14. Hamilton, Waikato Regional Council.

Tulagi A 2018. Regional rivers water quality monitoring programme: data report 2017. Waikato Regional Council Technical Report 2018/25. Hamilton, Waikato Regional Council.

Vant W 2018. Trends in river water quality in the Waikato region, 1993-2017. Waikato Regional Council Technical Report 2018/30. Hamilton, Waikato Regional Council.

Vant W 2019. Internal WRC memo - Water quality in streams in the catchments of Aotea and Kāwhia Harbours. (WRC document reference 15119510). Hamilton, Waikato Regional Council.

Waikato Regional Council 2014. Waipā Catchment Plan. Waikato Regional Council Technical Report 2014/33. Hamilton, Waikato Regional Council.

Waikato Regional Council 2016. West Coast Zone Plan Supporting Information. Unpublished report. Waikato Regional Council. (WRC document reference 4089579). Hamilton, Waikato Regional Council.

Waikato Regional Council 2017. Snapshot of coastal water quality in the Waikato region (2015-16). Waikato Regional Council unpublished.

Waitomo District Council. 2009. Waitomo District Plan. Te Kuiti, Waitomo District Council.

Wildlands Consultants Ltd. 2011. Significant Natural Areas of the Waikato Region - Lake Ecosystems. Report for Waikato Regional Council. Hamilton, Wildlands Consultants Ltd.

Wildlands Consultants Ltd. 2014. Significant natural areas of the Waitomo District - Terrestrial, wetland, and karst ecosystems. Volume 1. Contract No. 1080. Report for Waikato Regional Council. Hamilton, Wildlands Consultants Ltd.

Wildlands Consultants Ltd. 2016. Significant natural areas of the Ōtorohanga district: terrestrial and wetland ecosystems. Waikato Regional Council Technical Report 2016/36. Hamilton, Waikato Regional Council.