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Aotea catchment management plan supporting information

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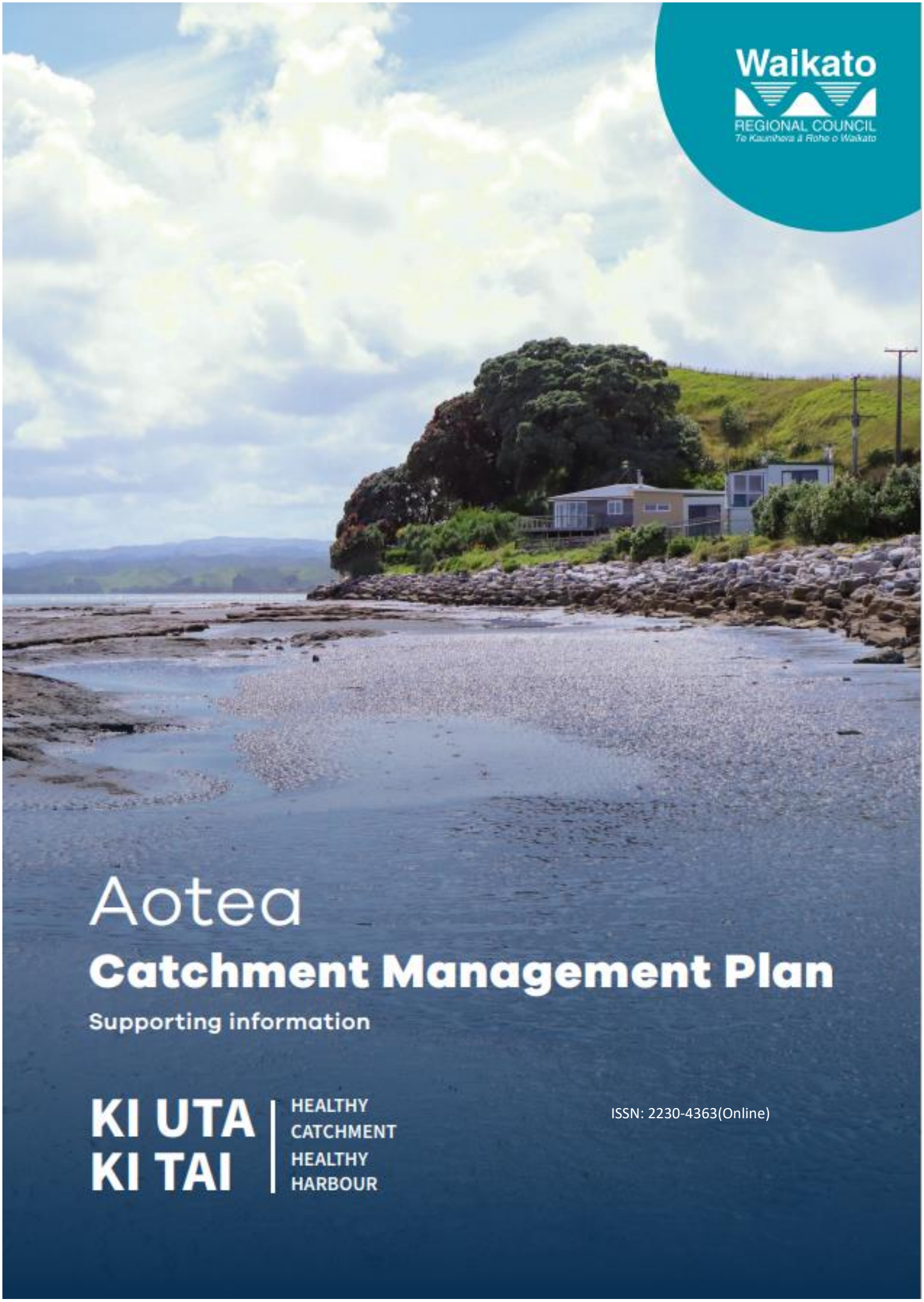

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Aotea
Catchment Management Plan
Supporting information

KI UTA KI TAI | HEALTHY CATCHMENT HEALTHY HARBOUR

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Aotea Catchment Management Plan: Supporting Information

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List of acronyms used in this document

CMA	Coastal Marine Area
ED	Ecological District
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

Executive summary

This report has been compiled to inform the development of the Aotea 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
- Hazard
- Climate change
- Prioritisation of conservation and restoration activities

A summary of the technical information is provided below.

The catchments of Aotea cover approximately 16,890 hectares of land along the west coast of the North Island of New Zealand. The Aotea catchment includes 244 kilometres of streams and has been divided into six sub-catchments by Waikato Regional Council for management purposes: North Harbour, Pakoka, Te Maari, Taparamapua, Okapu and South Harbour. Aotea harbour is the smallest of three drowned valley harbours on the Waikato's west coast covering approximately 3,100 hectares.

The Aotea harbour catchment is steep with 82% of the land being moderately steep or steeper, and prone to erosion. The cumulative effects of naturally unstable soils and extensive farming results in high sediment loads within some of these waterways. Just over half of the Aotea catchment is in pasture (54 %). More than a third (39 %) is in native woody cover that is located in the eastern hills of Pirongia Forest Park. Forestry accounts for approximately 3% of the catchment.

The Aotea catchment has changed and developed over time particularly since human settlement. Removal of native vegetation has resulted in increased area of pasture for farming and as other catchment and land use activities increased there has been a change in sediment generation, and a decline in water quality and indigenous biodiversity. Sediment has been identified as the most important and widespread water quality issue affecting the harbours and waterways of the West Coast harbours.

Waikato Regional Council does not have any long-term river or stream monitoring sites in the Aotea catchment. 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. *E.coli* levels are of concern in several rivers and streams in the Kāwhia catchment and this likely also applies to the Aotea catchment. Run-off and leaching from pastoral land use is the likely the main source of contaminants to the harbour, which is exacerbated during wet conditions.

Recent estuarine water quality monitoring in Aotea Harbour indicated a picture of overall good water quality and only slight pressure due to nutrients, sediments, and microbial contaminants. The harbour appears to experience mild pressures from nutrients, which was most prominent in winter months and inner harbour sites. This is likely due to nutrient run off into the streams affecting the estuary. It

is unlikely that swimming, recreational activities, or shellfish gathering has been impacted by microbial contamination.

Sediments in Aotea Harbour are mostly sandy with finer grain sizes closer to shore, and more fines associated with river and stream inflows. Sediment around the mouths of the Te Maari and Makomako streams are very muddy. Sediment contaminant levels in Aotea Harbour are low, indicating a low risk of toxic effects on sediment dwelling organisms.

Aotea harbour is one of the top 19 shorebird wintering sites in New Zealand and is nationally important for indigenous and international shorebirds including pied oystercatchers, banded dotterel, pied stilts, and Arctic migrants. Estuarine vegetation includes mangroves, salt marshes, seagrass, sea meadows and weed communities. Seagrass beds occur extensively across the middle tidal regions of Aotea harbour and these areas are important for the ecology of the harbour.

Swan and Canada geese populations have been identified as being an issue for the communities in the 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 Aotea harbour catchment were spartina, boneseed, evergreen buckthorn, prickly pear cactus, simlas, wild ginger, climbing asparagus and bamboo grass. Control programmes for targeted pest plants continue and the Department of Conservation is close to Spartina eradication.

The Waikato region is prone to natural hazards like coastal erosion, sand drift, wind erosion, coastal flooding, changes in sea-level, tsunami, storms, and cyclones. 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 as a result of climate change.

Prioritisation exercises undertaken by Waikato Regional Council in 2018 and 2021 have identified Te Maari and Taparamapua subcatchments 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 Aotea Catchment Management Plan.

1 Physical Characteristics of the Aotea Catchment

1.1 General Description

Aotea is the smallest of three drowned valley harbours on the Waikato's west coast covering 3,100 hectares (Figure 1). It is a shallow estuarine harbour with an extensive dune system to the north of the harbour mouth. The Aotea Harbour catchment has a land area of approximately 16,890 hectares.

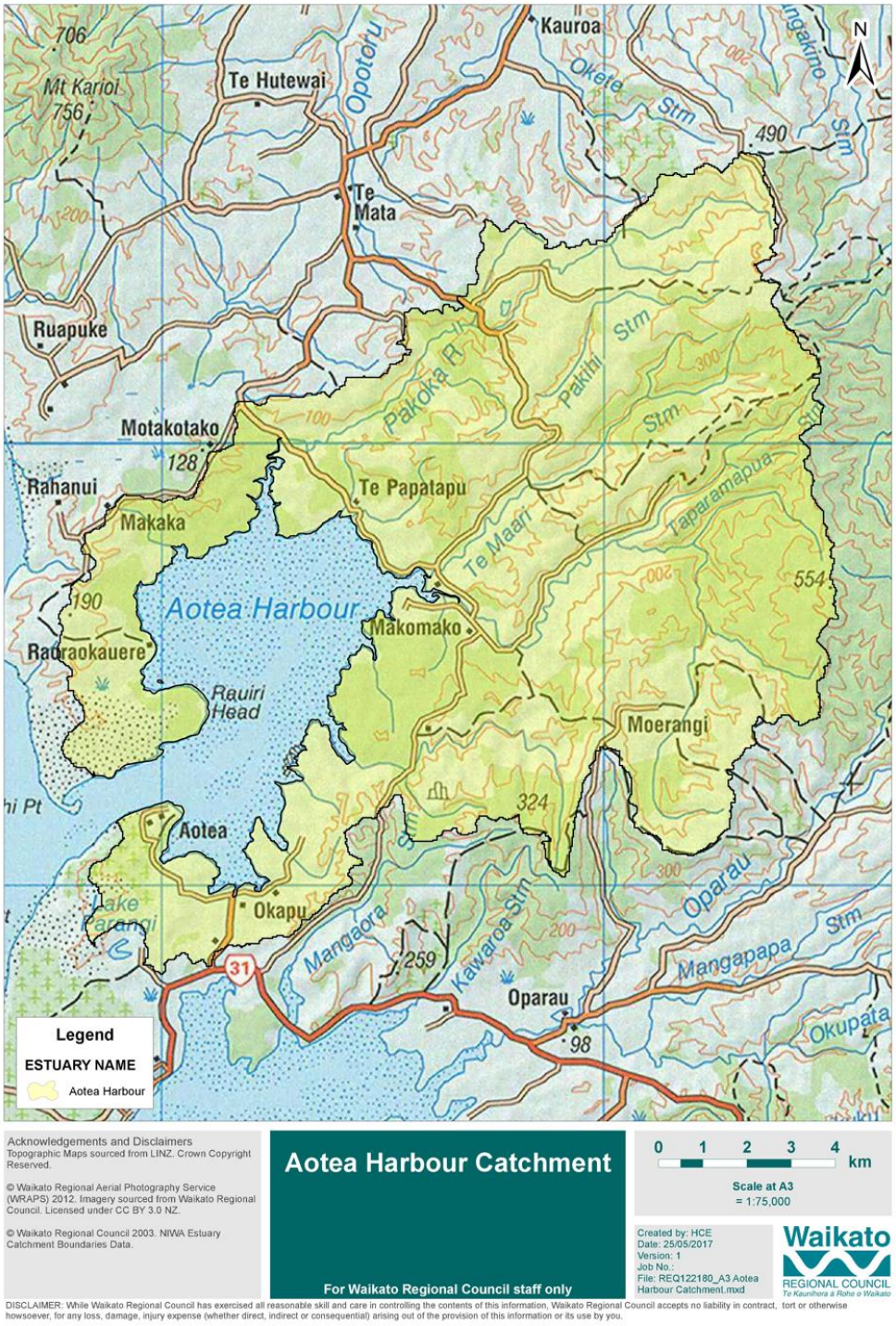

Figure 1. NZ Topographic map of the Aotea catchment.

For Waikato Regional Council management purposes the Aotea catchment has been divided into six sub-catchments : North Harbour (1230 ha), Pakoka (3522 ha), Te Maari (3023 ha), Taparamapua (4969 ha), Okapu (2023 ha), and South Harbour (1247 ha; Figure 2).

The Aotea catchment sits within the Waikato Regional Council West Coast zone. The zone 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 Aotea catchment are Ōtorohanga District Council (ODC), and Waitomo District Council (WDC).

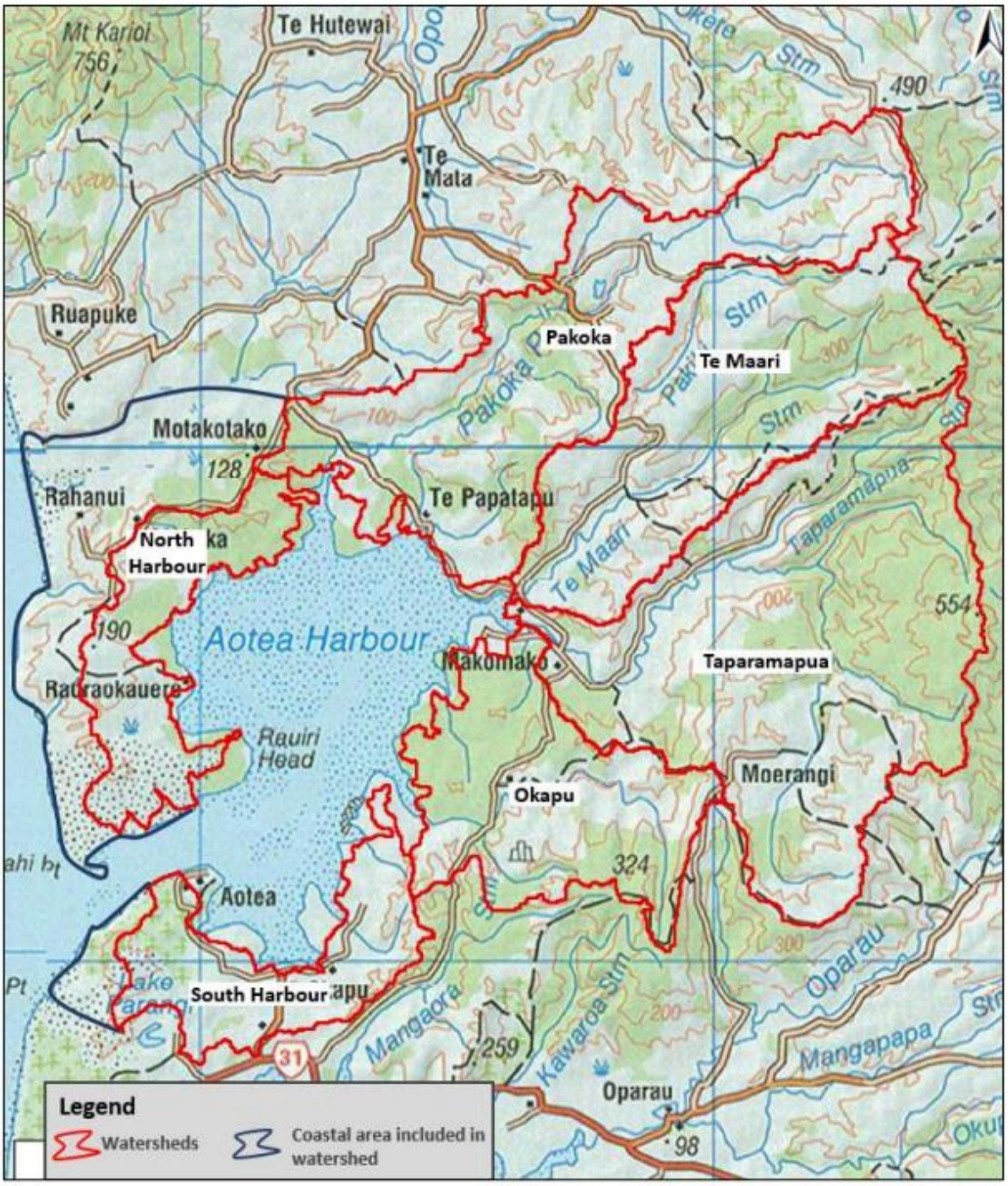

Figure 2. Aotea catchment with sub catchment boundaries.

The Aotea harbour catchment extends from sea level to about 500 m above sea level at the top of the Pakoka River sub-catchment. It carries on further inland into the headwaters of the Taparamapua and Te Maari Streams, which extend up the eastern side of the Pirongia Forest Park reserve (Singleton, 2018). Coastal forest regeneration provides an ecologically important vegetation sequence from the harbour edge to coastal and lowland forest in Aotea harbour.

Rainfall in the Aotea harbour catchment is high, with over 80% of the catchment receiving 1,400-1,700mm rainfall per year. In the highest parts of the catchment rainfall can reach 2,400 mm/yr (Singleton, 2018).

The harbour catchment is steep with 82% of the land being moderately steep or steeper, and prone to erosion. The cumulative effects of naturally unstable soils and extensive farming results in high sediment loads within some of the catchment waterways.

A large percentage (77%) of the Aotea catchment is siltstone and sandstone with 14% volcanic basalt and 8% coastal dune sand. Historically, 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). Graeme (2014) observed that Aotea harbour is mostly sandy with high levels of sediment accretion only noted in a few stream arms.

The Aotea catchment includes approximately 25 rivers and streams covering a length of 244 kilometres (Figure 3). The Makomako, Te Maari and Pakoka Rivers are the three largest, and their watersheds account for 71% of the catchment area (Greer et al., 2016).

Aotea Harbour has considerable cultural, and ecological values. Isolation, low intensity land use and low population density have helped to maintain the area in a relatively healthy and natural condition, although much of the original forest vegetation has been cleared for pasture. The coastal waters and harbour margins have been formally identified as areas with Outstanding Natural Character, and the harbour is recognised as an Area of Significant Conservation Value. Around 81% of the harbour is exposed at low tide and the large intertidal sandflat and mudflat areas provide habitat for diverse and abundant shorebird and benthic communities, including extensive beds of seagrass and shellfish. Aquaculture occurs in the channel adjacent to the main settlement, where wild mussel spat is harvested and sold to commercial growers of green lipped mussels elsewhere in New Zealand.

The dunefields at the mouth of Aotea harbour are nationally significant – as the largest example of their type on the West Coast of the North Island. These dunes have been used by Māori historically but are mostly unmodified. They are identified as important geopreservation features and are legally protected within the Aotea Heads Scientific Reserve, which includes the Potahi Point sand spit and Rauiri Head dune (Wildland Consultants Ltd., 2012).

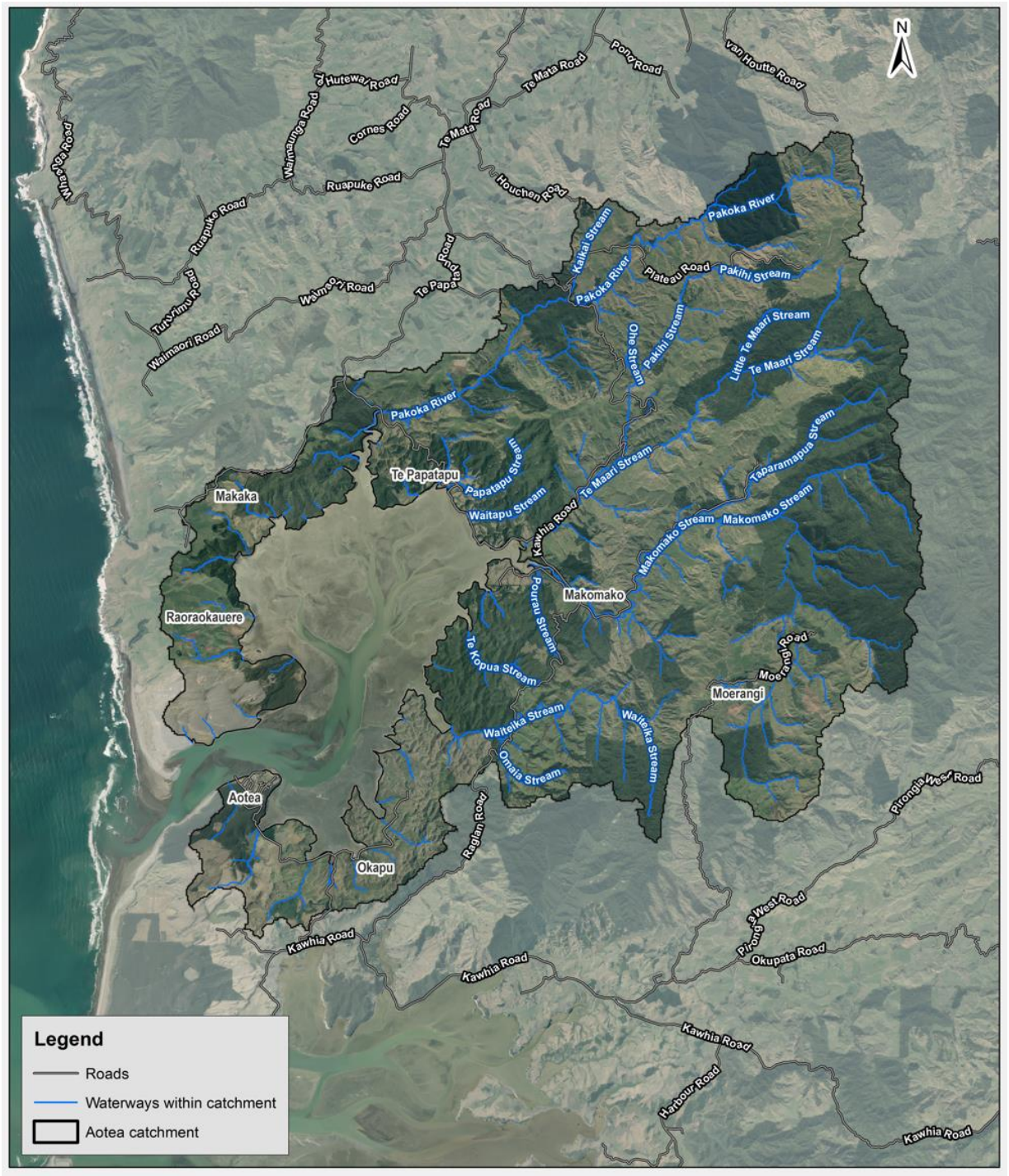

Figure 3. Aerial image of the key waterways within the Aotea Catchment

1.2 Land Cover

The current land cover within the Aotea Harbour catchment is shown in Figure 4 and is summarised in Figure 5 (Singleton, 2018). Just over half of the Aotea catchment is in pasture (54 %). More than a third (39 %) is in native woody cover that is located in the eastern hills of Pirongia Forest Park. Forestry accounts for approximately 3 % of the catchment, whilst there is uncertainty about the remaining 4 % (unspecified). There is very minimal built-up area within the catchment.

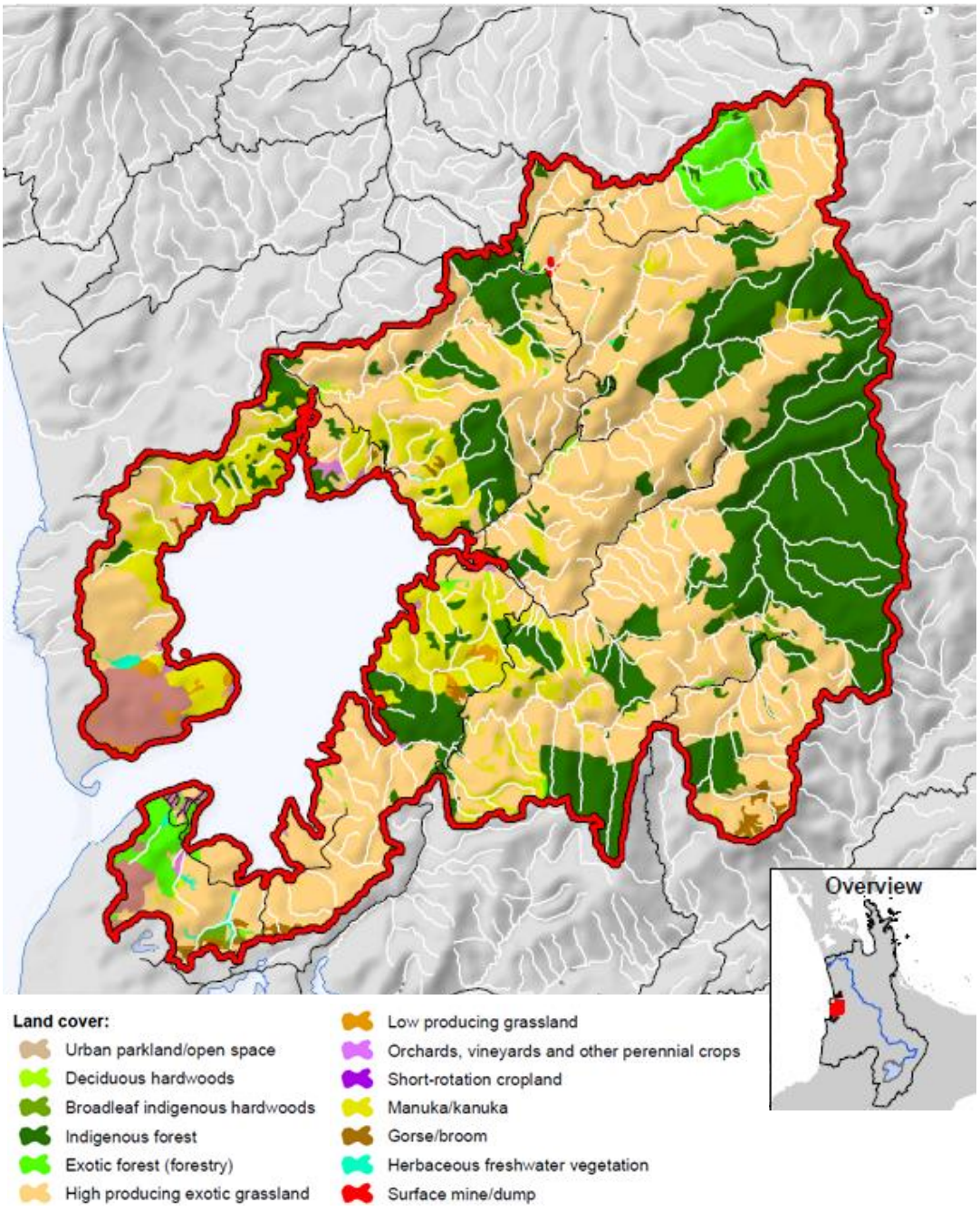

Figure 4. Overlay of land cover within the Aotea catchment

Wildland Consultants Ltd. (2014b) assessed the vegetation cover within each of the sub-catchments using LCDB3 as part of their Aotea harbour catchment condition survey[1]. They reported that 33.5 % of their study area had vegetation cover that provided effective catchment protection, while 66.5 % had lower stature vegetation that provided fewer catchment management services. Protective vegetation was greatest within the Okapu sub-catchment (59.9 %), and lowest within the Te Maari sub-catchment (13.6 %), excluding forested headwaters in public conservation land. The results from the survey are provided in Table 1. Vegetation coverage (ha) and protection services within the sub-catchments of the Aotea catchmentTable 1.

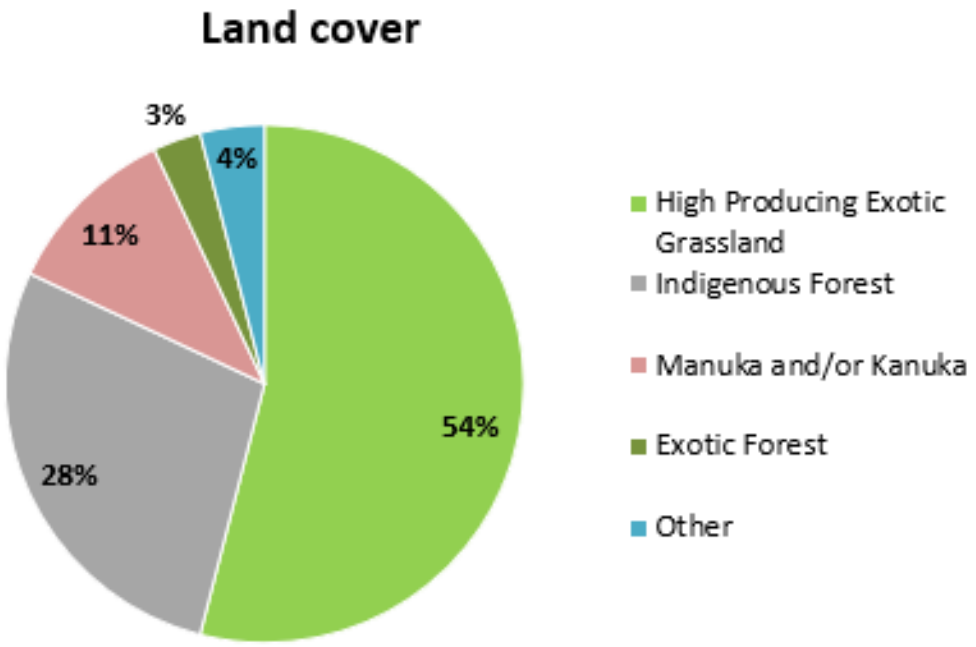

Figure 5. Percentage of land cover within the Aotea catchment (Singleton, 2018).

Table 1. Vegetation coverage (ha) and protection services within the sub-catchments of the Aotea catchment (Wildland Consultants Ltd., 2014)

Sub-Catchment	**Higher Level of Catchment Protection: Forest, Scrub, Wetlands**	**Lower Level of Catchment Protection: Pasture, Cropland, Built-Up Areas**	**Total**
North Harbour	597.4 (52.5)	539.8 (47.5%)	1,137.2
Okapu	1,193.1 (59.9%)	797.3 (40.1%)	1,990.3
Pakoka	1,058.2 (32.8%)	2,166.7 (67.2%)	3,224.9
South Harbour	402.3 (26.3%)	1,126.2 (73.7%)	1,528.5
Taparamapua	972.9 (29.1%)	2,369.0 (70.9%)	3,341.9
Te Maari	313.1 (13.6%)	1,990.1 (86.4%)	2,303.1
Total	**4,536.9 (33.5%)**	**8,989.0 (66.5%)**	**13,525.9**

[1] Of accessible private land in Aotea harbour

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. It is a natural phenomenon which results in soil losses and can lead to water quality degradation. New Zealand is geologically young and active and, as a result, the natural level of erosion is high by international standards. 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. Soil is a finite resource. Once erosion has occurred, the productivity of the soil rarely returns to its former level.

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.

Data in the Land Resource Inventory indicates that 82% of the Aotea catchment is moderately steep or steeper (Figure 6Figure 6. Slope classes within the Aotea Harbour Catchment). 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. Fifteen percent is rolling to strongly rolling (8-20 degree slope), and this has a slight erosion risk when cultivated (Singleton, 2018).

The slope of the land in the Aotea catchment is a major constraint on land use development because of the risk of erosion and soil loss. In general, moderately steep land (and steeper) is rarely cultivated due to a high risk of erosion limiting the number of crop rotations possible.

Summary statistics regarding erosion risks within the Aotea catchment (Table 2) were documented in the unpublished report to inform the West Coast Zone Plan (Waikato Regional Council, 2016a). In the Aotea catchment there is an estimated sediment loss of 197 tonnes/km^2/yr. The hill country has moderate to high rainfall (1,400 to 2,400 mm) in the headwaters and is prone to shallow slip and sheet erosion, particularly where heavy livestock are grazed on steep land (Singleton, 2018).

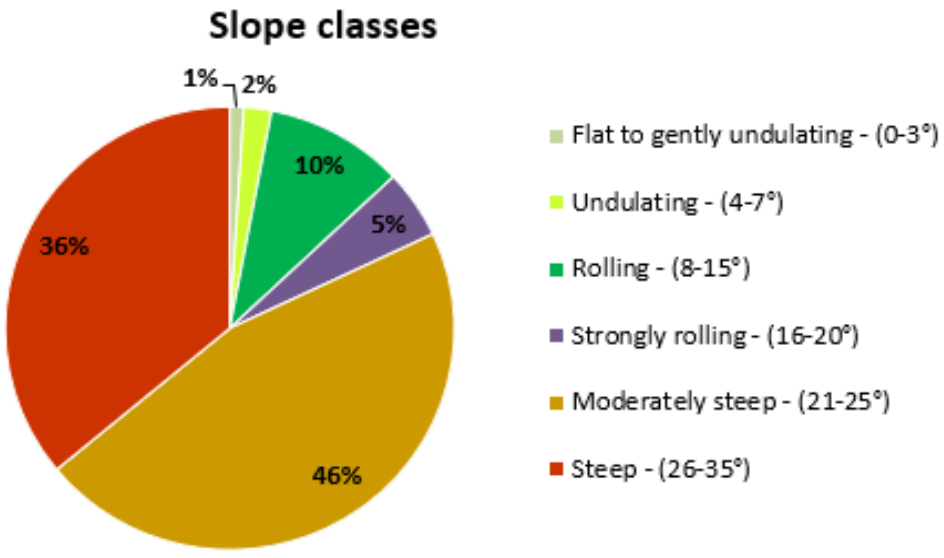

Figure 6. Slope classes within the Aotea Harbour Catchment (from Singleton, 2018).

Table 2. Summary of erosion risk within the Aotea catchment and comparison to Whāingaroa and Kāwhia catchments (Waikato Regional Council, 2016a).

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

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.

There are still many watercourses in the catchment with little or no erosion protection in place or where stock can access, accelerating stream bank erosion. The 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 erosion and sedimentation problems.

Wildland Consultants Ltd. (2014) visually inspected the margins of streams within the Aotea catchment in 2013 and found that the mean proportion of riparian erosion was 22.3 % of total riparian length. Mean proportions of riparian erosion for the sub-catchments varied considerably, ranging from 5.8 % (Pakoka) to 45.9 % (Okapu) refer Table 3.

Table 3. Extent (length in meters) of riparian erosion within the Aotea sub catchments (Wildland Consultants Ltd., 2014)

Sub-Catchment	**Both Sides with Riparian Erosion (m)**	**%**	**One Side with Riparian Erosion (m)**	**%**	**Total**
North Harbour	0	0.0	698	5.9	5.9%
Okapu	12,111	20.3	3,134	5.3	45.9%
Pakoka	3,160	1.8	3,740	2.2	5.8%
South Harbour	1,870	3.9	3,858	8	15.7%
Taparamapua	21,464	13.6	4,615	2.9	30.2%
Te Maari	18,772	12.6	3,113	2.1	27.2%
Total	**57,378**	**9.6**	**19,158**	**3.2**	**22.3%**

1.3.3 Landscape erosion

Erosion is typically evident as numerous, small features scattered throughout the Aotea catchment on locally steep slopes in pasture. When the catchment condition survey was carried out in 2013, the total eroded area of the Aotea Harbour catchment was 194 ha, or 1.5% of the area that was surveyed (Wildland Consultant Ltd.,2014). Mass movement erosion, slips, and slumps accounted for 69% of

erosion recorded by area, and 86% of the total number of erosion sites. The Taparamapua, Te Maari, South Harbour, and Okapu sub-catchments had the highest number of erosion sites per unit area.

Table 4. Type, number, and area (ha, in brackets) of erosion sites within the Aotea Harbour sub-catchments (Wildland Consultant Ltd., 2014)

Sub-Catchment	**Erosion Type**						**Percentage of Total Area**	**Erosion Sites/ 100 ha**
	Gully/ Tunnel	**Mass Movement Slips Slumps**	**Sheet/ Rill**	**Stream Bank**	**Harbour Edge**	**All**		
North Harbour		7 (2.5)				7 (2.5)	0.2%	0.6
Okapu		178 (25.4)	7 (1.4)	1 (0.1)		186 (26.8)	1.3%	9.3
Pakoka		181 (17.9)	9 (1.9)	1 (0.0)		191 (19.9)	0.6%	5.9
South Harbour		138 (17.6)	18 (13.1)		7 (1.6)	163 (32.3)	2.1%	10.6
Taparamapua	11 (2.3)	296 (45.6)	52 (27.9)	3 (0.8)	6 (0.8)	368 (77.3)	2.3%	11.0
Te Maari	25 (2.4)	236 (25.0)	24 (6.9)	3 (0.1)	5 (0.6)	293 (35.0)	1.5%	12.7
Total	**36 (4.6)**	**1,036 (133.8)**	**110 (51.3)**	**8 (1.0)**	**18 (3.0)**	**1,208 (193.8)**	**1.5%**	**9.0**

Much of this erosion damage occurred during the winter of 2013, which local farmers reported had been significantly wetter than average Table 4 summarises the results of the catchment condition survey. Climate change is expected to result in more frequent extreme rainfall events, further exacerbating erosion problems.

1.3.4 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], which can occur over long periods of time. Short-term erosion can also be caused by storms without causing a permanent change in the position of the shoreline. The area usually recovers; however, a full erosion and accretion cycle can take several decades. Climate change is expected to result in more frequent extreme rainfall events, further exacerbating erosion problems.

The open coast beaches near the Aotea Harbour, the sub-tidal spit on the northern side of the entrance, and the shorelines to the south are likely very dynamic and considerable shoreline fluctuations may occur (Tonkin and Taylor Ltd., 2008). The shoreline along the front of Aotea township is extremely dynamic and shoreline surveys dating from 1889 reveal major shoreline fluctuations and changes. As of 2008, the most recent significant shoreline changes occurred in the 1960's and 1970's when the shoreline retreated by up to 125 m over a distance of several hundred metres (Tonkin and Taylor Ltd., 2008).

[2] gradual washing away of land along the shoreline

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

1.4 Land suitability for production

1.4.1 Land Use Capability Classification

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 Aotea catchment

The LUC classes of the Aotea catchment are shown in Error! Reference source not found.**.** Overall, the ability to use land in the catchment for production is limited with 85% of the catchment assigned LUC class 6, 7 or 8. Fourteen percent of the catchment falls into LUC classes 3 and 4. The catchment does not have any highly versatile land (LUC classes 1 or 2).

For the Aotea catchment the area of pasture (54% of the catchment) equates to approximately 9,120 hectares. Of this 74%, or 6,703 hectares, is in pasture on class 6e land and less than one hectare is on class 8 land. At this high level, no areas of high producing exotic grassland are identified on LUC class 7 land, although there are likely to be pockets throughout the catchment.

Table 5. Summary of the LUC classification for the Aotea Harbour catchment

LUC Class	Description	Area	% Catchment
3	Moderate limitations – can be used for cultivated crops, pasture or forestry	240	1.4
4	Land with severe limitations to arable use. Careful management required. Usually kept in pasture for long periods	2181	13
6	Mostly good, fairly stable, hill country where soil erosion can be minimised by good pasture establishment and management. Well suited to grazing and forestry.	12267	73.3
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.	1748	10.4
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.	322	1.9

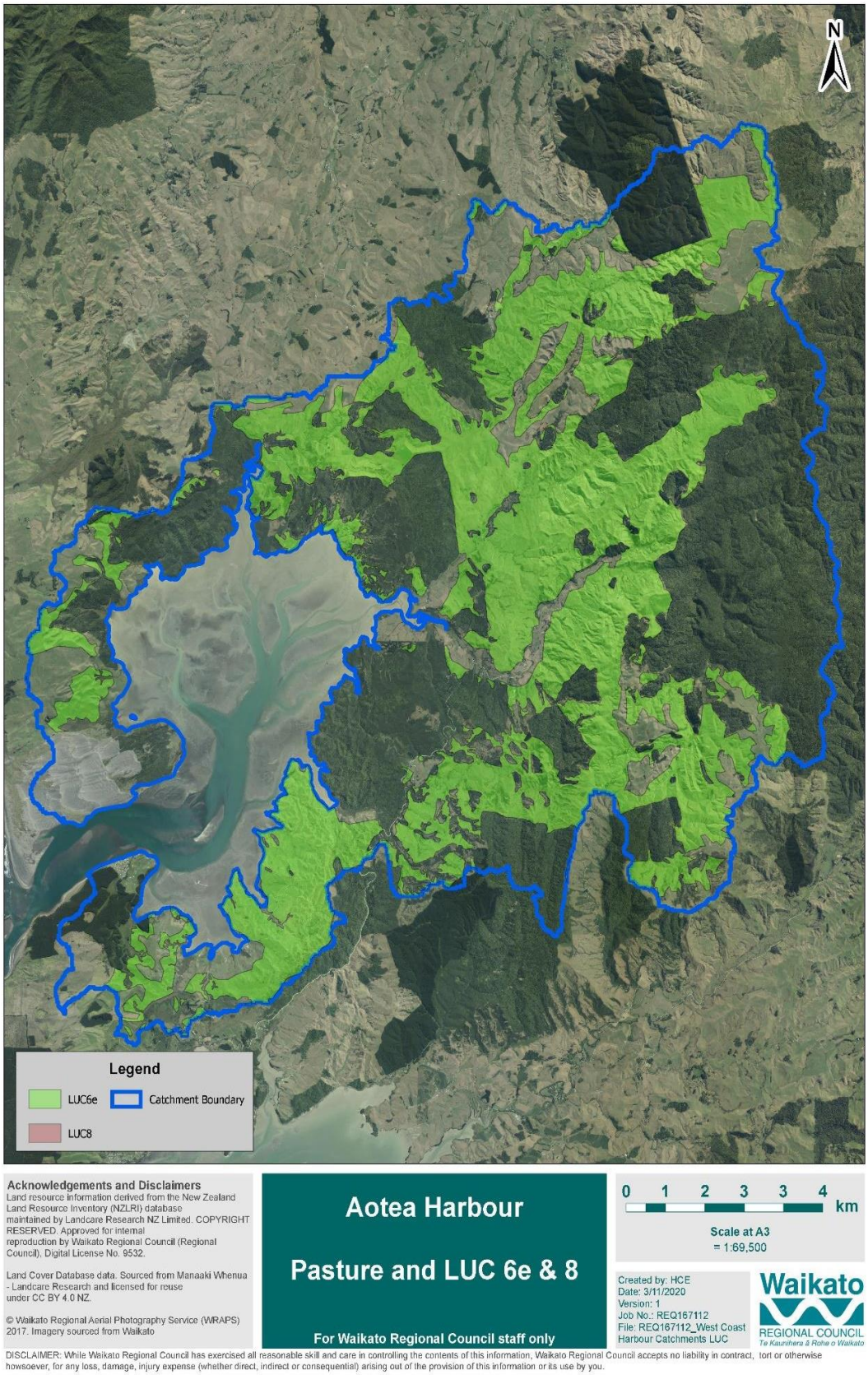

Figure 7. Map of LUC 6e and 8 class land with pastoral land use within the Aotea Catchment

2 Catchment land use and activities

2.1 Introduction

The way we use 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. As shown in Figure 8, the predominant land use within the Aotea harbour catchment is pastoral sheep and beef farming (55%), followed by native bush (21%). There is uncertainty about the usage of 22% of the catchment area (Singleton, 2018).

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

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

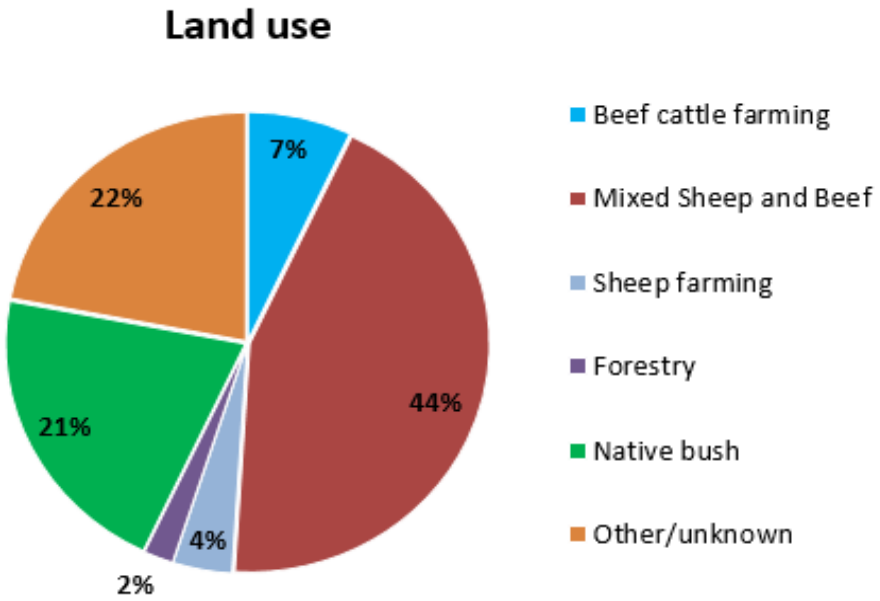

Figure 8. Land use types within the Aotea Harbour Catchment (Singleton, 2018).

2.2 Urban and rural development

The Aotea community has a current population of approximately 258 people[4], which has declined over recent years, and is much smaller than it has been historically.

The main harbour settlement is Aotea village, which is located at the southern end of the harbour margin and has been subject to some development, including reclamation and erosion control, and recent subdivision.

Most of the properties in the Aotea catchment are privately owned. As of 2020 there were a total of 483 individual properties[5], including: 30 in Crown ownership; 72 in Māori freehold land; and 381 in private ownership. The majority of properties within the catchment are rural/lifestyle properties, with a total of about 180 residential properties within the catchment.

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 versatile (or highly productive) land and that further loss may reduce economic opportunity. However, considering the small proportion of developed land in the Aotea catchment, coupled with decreasing population rates, it is unlikely that this is a problem.

2.3 Coastal development

The coastline of the Aotea catchment is relatively undeveloped and consists of a mix of extensive harbour beaches, sand spits and sea cliffs. There are various types of hazards including flooding, coastal erosion and landslips (discussed further in section 7) that can put property and lives at risk.

2.4 Legally protected land and conservation activities on private land

A sizeable amount of land in the Aotea catchment is held as public conservation land, and in multiple-Māori ownership. Approximately 3100 hectares (18.3%) of the Aotea catchment area is administered by DOC as public conservation land to protect its natural, scenic and recreational values[6]. Additional mechanisms for legal protection of private land include:

- QEII National Trust[7]: The Queen Elizabeth II (QEII) National Trust partners with landowners to voluntarily secure the long-term protection of natural and cultural features on private land with 'open space' covenants. Features protected include landscapes, forest remnants, wetlands, grasslands, threatened species habitats, and cultural and archaeological sites (QEII National Trust, 2017).
- Ngā Whenua Rāhui[8]: A contestable fund that is serviced by DOC and provides funding for the protection of indigenous ecosystems on Maori-owned land, with the protection mechanism being a kawenata (covenant).

A total area of 123 hectares in the Aotea catchment is protected under QEII agreements, while 59.5 hectares are protected by Ngā Whenua Rāhui. In total, 19.4% (3,280 ha) of the Aotea catchment is protected by QEII, Ngā Whenua Rāhui or DOC, to protect biodiversity values.

[4] Statistics NZ 2013

[5] Rating units by ownership type

[6] Held under conservation legislation, e.g. the Conservation Act 1987, and Reserves Act 1977

[7] https://qeiinationaltrust.org.nz

[8] https://www.doc.govt.nz/ngawhenuarahui

2.5 Plantation forestry

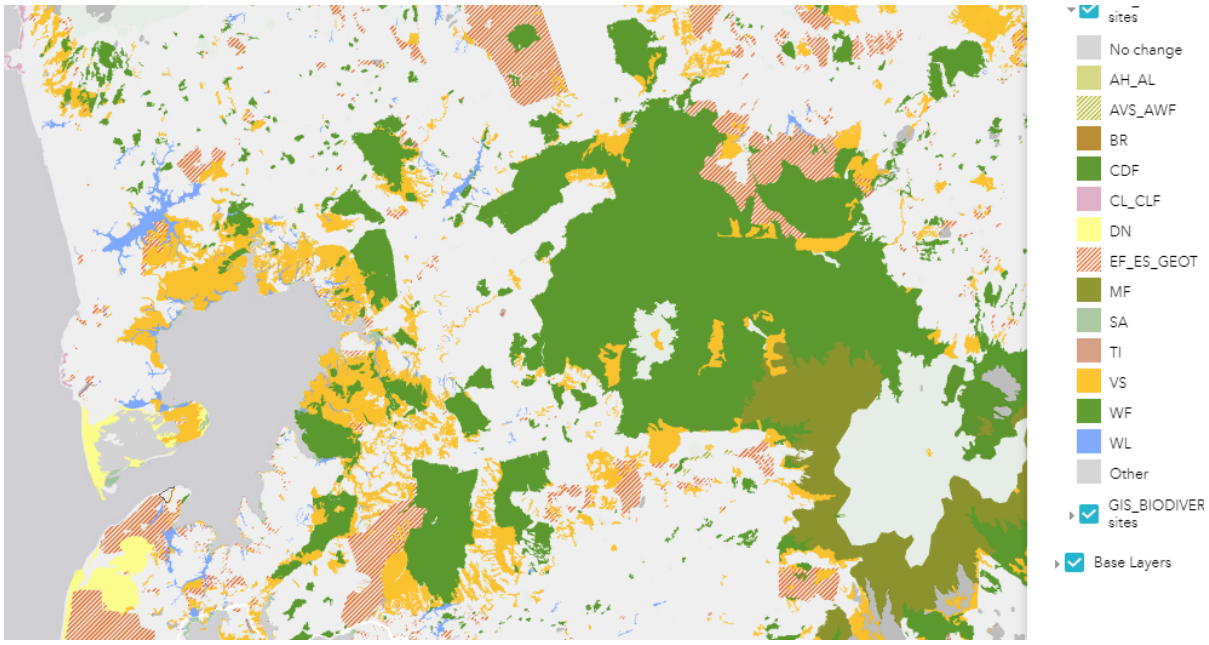

Figure 9. Snapshot of biodiversity inventory layer 2012, with plantation forest in the Aotea catchment shown in orange diagonal stripe labelled EF_ES_GEOT.

A very small portion of the Aotea catchment, approximately 2%, 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.

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

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 will 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.

2.6 Farming

Farming related land cover makes up approximately 55% of the Aotea catchment, including high and low producing grassland used for mostly drystock and a small amount of dairy farming. Farming adversely affects the catchment if farm runoff enters adjacent rivers and streams and nutrients, sediment and pathogens are transported through the water network. Adverse effects can also arise from farmland erosion, particularly along waterway margins. The Aotea 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 (taking up nutrients before they reach the water), remove nitrogen and prevent stock access when fenced (reducing bank erosion from trampling, and reducing the amount of effluent reaching the water). Many of these mitigation measures are implemented in the Aotea catchment with a particular focus on riparian management of pastoral waterways.

Fencing is an important pre-requisite for the establishment of riparian vegetation that can help filter[9] surface run-off from agricultural land to remove sediment, nutrients[10] and faecal matter before it reaches the waterway. Woody riparian vegetation (e.g., shrubs and trees) provide additional biodiversity benefits by creating habitat for terrestrial and aquatic life, stream shading for regulating water temperature and aquatic plant growth, and improved stream-bank stability (Jones et al., 2016).

Waikato Regional Council actively promotes[11] the fencing and planting of riparian margins. The Council has regularly[12] surveyed the riparian margins of more than 300 stream reaches across the region to assess the extent of fencing, vegetation and erosion in riparian margins through pastoral land (Storey 2010; Jones et al., 2016, Norris et al., 2020). This work highlighted the West Coast zone as 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%).

Graeme (2014) identified a widespread need for fencing of all agricultural land next to Aotea harbour, with the following areas identified as priorities at the time:

- Kaingata Stream embayment
- True left bank of the Waiteika Stream mouth
- North of Orotangi Cliff
- Kakawa Point
- The heads of several estuarine/freshwater wetlands, including Te Kowiwi creek and the embayment on the other side of Kakawa point

A catchment condition survey undertaken in 2013 found that only 11.9% of riparian margins were stock-proof on both sides of streams and rivers within the Aotea catchment at that time (Table 6). The North Harbour sub-catchment was the only apparent exception, as most streams running through pasture appeared[13] to be fenced, and 52.5% of the sub-catchment contained forest and/or scrub that stock was excluded from (Wildland Consultants Ltd., 2014).

[9] By encouraging the deposition of

[10] particularly P associated with the sediment

[11] via the Clean Streams project, Project Watershed, and other funding initiatives

[12] In 2002, 2007, 2012 and 2017

[13] NB. access to several private properties within the North Harbour sub-catchment was limited

Table 6. Extent (meters) of stock-proof riparian margins within the Aotea Harbour sub-catchments in 2013 (Wildland Consultants Ltd., 2014). Sub-catchments are shown in Figure 2.

Sub-Catchment	Both Sides Stock-Proof	One Side Stock-Proof	Total
North Harbour	5,023 (85.4%)	0 (0.0%)	11,758 (85.4%)
Okapu	1,055 (3.5%)	1,915 (6.4%)	59,576 (6.8%)
Pakoka	4,178 (4.8%)	8,109 (9.4%)	172,500 (9.5%)
South Harbour	1,273 (5.3%)	4,262 (17.6%)	48,380 (14.1%)
Taparamapua	3,377 (4.3%)	8,474 (10.8%)	157,516 (9.7%)
Te Maari	3,223 (4.3%)	12,224 (16.4%)	149,468 (12.5%)
Total	**18,129 (6.1%)**	**34,984 (11.7%)**	**599,199 (11.9%)**

Table 7. Extent (in meters) of coastal margin fencing in the Aotea Harbour sub-catchments in 2013 (Wildland Consultant Ltd., 2014).

Sub-Catchment	Not Stock Proof	Stock Absent2	Stock-Proof	Total Length of Coastal Margin
North Harbour			4,978 (100.0%)	4,978
Okapu	2,303		6,223 (73.0%)	8,526
Pakoka	706	3,116	2,037 (34.8%)	5,859
South Harbour	7,859	2,562	7,545 (42.0%)	17,966
Taparamapua	1,106		884 (44.4%)	1,990
Te Maari	N/A	N/A	N/A	N/A
Total	**11,974**	**5,678**	**21,668 (55.1%)**	**39,321**

Graeme (2014) identified agricultural land use as a threat to Aotea Harbour and identified unfenced farmland as a major source of sediment, nutrients and pathogens entering the harbour. With unrestricted access, stock physically damage the harbour vegetation and water quality by pugging sediments and vegetation, grazing vegetation, spreading[14] weed species such as spartina and saltwater paspalum, and defecating directly into the harbour.

The results from the 2013 Wildland Consultant Ltd. survey in Table 7 shows that approximately 55% of the harbour margin was protected from stock access, mainly as a result of fencing, or the absence of stock on adjoining coastal land (built-up areas, road reserves). Across the six sub-catchments the degree of stock-proofing of the coastal margin ranged from 34.8% (Pakoka) to 100% (North Harbour).

2.7 Tourism

The Aotea catchment provides opportunities for boating, fishing, swimming and other ocean activities. Over the summer months the population can become larger than the usually 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.

3 Erosion and Sediment

3.1 Overview of sediment-related issues in waterways

Sediment has been identified as the most important and widespread water quality issue affecting the waterways and harbours of the West Coast. The steep hills, unstable geology and high rainfall make

[14] Grazing of weed species (i.e.*Spartina* and saltwater paspalum) can facilitate their spread by dislodging fragments that can be moved in the tide or by physically transferring them.

catchments naturally vulnerable to erosion. Some land uses, including farming, which is prevalent in the Aotea catchment[15] exacerbates erosion risk, particularly along waterway margins. The eroded areas produce sediment and are slow to recover. Erosion can have a number of physical impacts on water and other infrastructure - fence lines, culverts, tracks and others (Singleton, 2018).

Sediment naturally occurs in waterways. Excess sediment can increase water turbidity (make water cloudy), infill streams and estuarine embayments, 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 animal (including shellfish) diversity decreases with an increase in mud. 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 Aotea Harbour catchment. Additional information on suspended sediment in rivers and streams is provided in section **Error! Reference source not found.** and suspended sediment in Aotea Harbour is also discussed in section **Error! Reference source not found.**.

3.2 Sources of excess sediment

The main sediment issues for the Aotea catchment are generated in the hills of the upper catchments. Many landslips have occurred since the historic deforestation of the catchment. Studies have shown that the root systems of trees increase soil strength by 30% or more compared to pasture (described in Singleton, 2018). Deforestation has therefore reduced soil resistance to landslides. Storm events with moderate intensity can now cause erosion, while much greater storm intensities are 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 Aotea catchment's harbours, estuaries and karst systems are particularly vulnerable to high sediment input. As described in previous sections, land use and activities, including, vegetation clearance, agricultural intensification, and farming without effective erosion protection can cause or contribute to sediment generation.

3.3 Suspended sediment in rivers and streams

Waikato Regional Council regularly monitors the water quality of 14 streams within the West Coast Zone. There is no monitoring site within the Aotea catchment for water quality and therefore no data. Due to the nature of the Kāwhia and Aotea catchments and their similar topography, land cover, rainfall and land use, it is reasonable to assume that suspended sediment in rivers and streams of these catchments is similar. Turbidity and water clarity in the Kāwhia catchment are variable, generally satisfactory with significantly increased suspended sediment loads during wet weather. An example of high suspended sediment inflow to Aotea Harbour from the catchment (Te Maari and Taparamapua streams) is shown in Figure 10.

[15] See section **Error! Reference source not found.**.

Figure 10. Te Maari and Taparamapua streams discharging sediment into Aotea harbour (Image: Google Earth).

3.4 Sediment yields in Aotea Harbour

An estimate of sediment yields within the wider Waikato estuaries was published in 2004 and this estimated that the sediment yield from the catchment into Aotea harbour was approximately 33,400 tonnes per year. Aotea harbour ranked seventh highest for relative sediment yield of all 29 estuaries in the Waikato region. 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).

3.5 Sediment contaminants and muddiness in Aotea 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 2008 sediment study of Aotea Harbour 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 (Rumsby, 2009). The concentrations of most trace elements were at the lower end of the estimated natural range (as represented by regional soil concentrations) and no trace elements were present in concentrations which exceed the ANZECC (2000) ISQG-low guideline values. Rumsby (2009) concluded that, overall, the sample results show little evidence of anthropogenic effects on the sediment quality of Aotea Harbour.

Sediment samples from Aotea Harbour were mostly sandy with finer grain sizes closer to shore, and more fines associated with river and stream inflows. Sediment samples collected from around the mouths of the Te Maari and Makomako streams were very muddy, comprising over 86% fines (Rumsby, 2009). The sediment quality in Aotea Harbour (as well as Kāwhia and Whāingaroa harbours) was assessed as “good” and indicated a low risk of toxic effects on sediment dwelling organisms.

4 Water quality

4.1 Introduction

Water quality in catchment rivers and streams as well as estuaries can be affected by a wide range of stressors. As described in section 3, sediment input is an important cause of water quality issues in the Aotea catchment rivers and streams. Excess suspended sediment in rivers, streams, and estuaries increases turbidity and reduces water clarity. This can affect the ecological health of waterbodies in a number of ways, including by impairing the foraging efficiency of visually hunting fish and birds, causing some migratory fish species to avoid highly turbid rivers, reducing benthic plant growth or making locations unsuitable for benthic plants, and reducing growth rates of periphyton and macrophytes on river beds.

This section outlines the state and trends of water quality within saline and freshwater bodies located within the Aotea Harbour Catchment.

4.2 Freshwater quality within the catchment

4.2.1 River and streams

Waikato Regional Council regularly monitors the water quality of 14 rivers and streams within the West Coast Zone, between Whāingaroa and Mokau. None of these sites occur in the Aotea catchment, but recent analysis[16] suggests that the water quality of the streams in the Aotea catchment is likely to be similar to the combined dataset for the other 14 West Coast stream sites (Vant, 2019). The average water quality of these sites is shown in Table 8.

Based on the water quality conditions indicted by Table 8, it is likely that the waters of streams and rivers in the Aotea catchment are generally well-oxygenated, of neutral pH, moderately turbid, have low levels of ammonia, moderate to high levels of total N, moderate levels of total P, and high levels of faecal bacteria contamination (*E. coli*). Runoff and leaching of contaminants from the land is likely to be the main source of contaminants to these streams, with pasture contributing more than areas in forest and scrub (Vant, 2019).

[16] Based on the well-established relationship between landuse type and intensity and water quality

Table 8. Median water quality during 2013–17 in 14 stream sites in the West Coast zone of the Waikato Region (averages of the corresponding 14 medians), and number of sites showing important trends during the period 1993-2017. Source: Vant (2018, 2019).

	Average water quality of 14 West Coast stream sites	**WRC water quality guideline category (excellent, satisfactory, unsatisfactory)**	**Number of sites showing important trends (1993-2017)**	
			Improvement	**Deterioration**
Ecological health				
Diss oxygen (% sat)[17]	99	Excellent	0	0
pH	7.5	Excellent	n/a	n/a
Turbidity (NTU)	6.6	Unsatisfactory	5	0
Ammonia (g N/m^3)	0.01	Excellent	5	0
Total N (g/m^3)	0.54	Unsatisfactory	1	2
Total P (g/m^3)	0.026	Satisfactory	7	0
Contact recreation				
Clarity (m)	1.0	Unsatisfactory	3	0
E. coli (cfu/100 mL)	200	Unsatisfactory (based on 95th percentile of *E. coli* data[18])	1	0

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 11 provides the 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 programme (Sula, 2021). *E.coli* is the parameter of concern for the Kāwhia catchment; it is at levels that pose a realistic risk to swimmers and high when compared to other sites in the Waikato region as well as other lowland rural sites in New Zealand. As described in above, it is likely that *E. coli* levels are similar in the Aotea catchment.

[17] "Diss" = dissolved; "sat" = saturation concentration

[18] https://www.waikatoregion.govt.nz/environment/natural-resources/water/rivers/water-quality-monitoring-map/, accessed 15 April 2023.

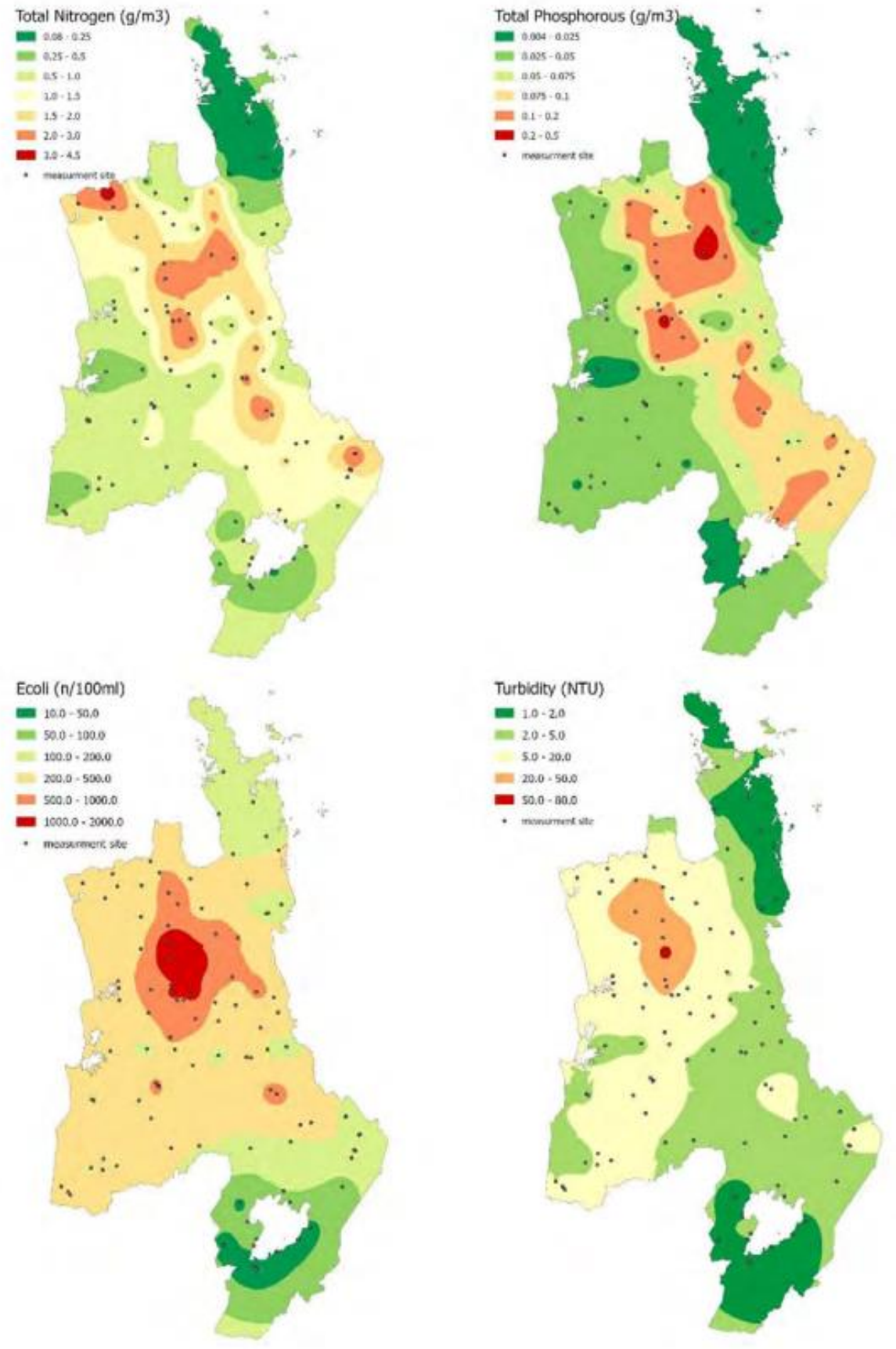

Figure 11. Spatial contour plots of four water quality parameters (based on 5-year median values, 2016-2020); Total Nitrogen, Total Phosphorus, *Escherichia coli*, Turbidity (Sula, 2021).

4.2.2 Groundwater quality

There is little information available on groundwater quality within the catchment, although it is understood that properties in Aotea village are reliant upon groundwater for domestic water supply.

4.2.3 Summary – Freshwater quality

Waikato Regional Council does not have any long-term monitoring sites in the Aotea catchment and therefore data from the 14 West Coast stream monitoring sites, including the Kāwhia catchment, has been used to develop a picture of water quality. 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. *E.coli* levels in several rivers and streams are of concern for the Kāwhia catchment and this likely also applies to the Aotea catchment. Run-off and leaching from pastoral land use is the likely 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 Estuarine water quality

Waikato Regional Council has undertaken water quality monitoring within Aotea harbour since 2019 as part of its estuarine water quality monitoring programme and has previously collected recreational water quality information from the main village area of the harbour.

Monthly estuarine water quality monitoring has been undertaken at three locations (Pakoka-Te Maari, North Harbour and Mixed; Figure 12) between April 2019 and March 2021 to determine the state and trends of water quality for ecological health. Microbial information is also collected from these sites during sampling, which relates to recreational suitability. Recreational water quality monitoring was also carried out for enterococci at one site in Aotea Harbour in 1996/97 and between 2001-2009 every second season for enterococci and faecal coliforms.

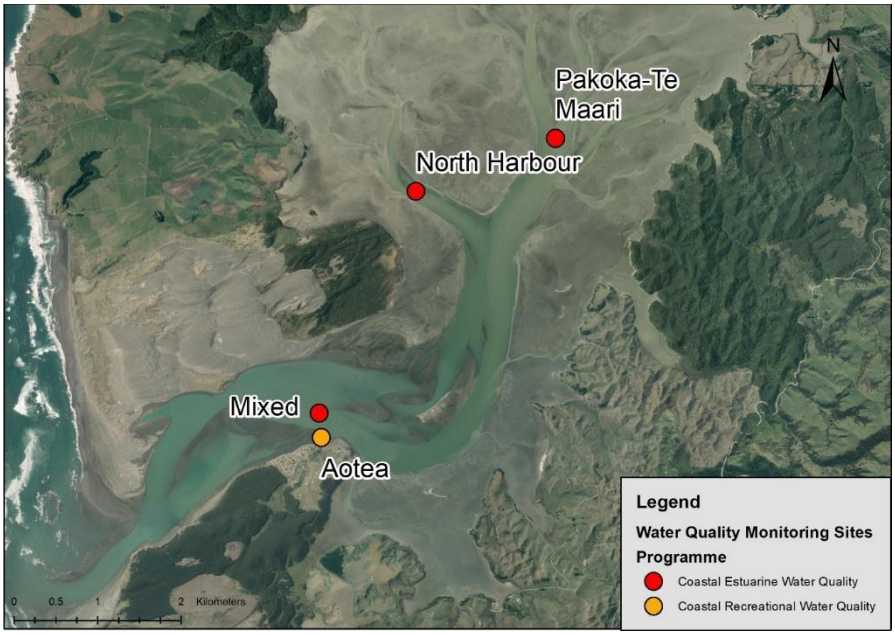

Figure 12. Map showing locations of estuarine (red dots) and recreational (orange dots) water quality monitoring stations at Aotea Harbour. Source: Kamke (2021).

Estuarine water quality monitoring in the harbour showed a preliminary picture of overall good water quality and only slight pressure due to nutrients, sediments, and microbial contaminants (Kamke, 2021). Monitoring results are shown in Figure 13. Throughout the 2019-2021 monitoring period the water column remained well oxygenated at all monitoring stations. Chlorophyll a concentrations were similar at all monitoring stations and remained well below the ANZECC guideline value of 0.004 mg/L at all times. No obvious seasonal differences in chlorophyll a concentrations were detected.

Total nitrogen and nitrate-nitrite nitrogen remained under ANZECC guideline values at all stations. At Mid Harbour, median ammoniacal nitrogen concentration also remained below the ANZECC guideline of 0.015 mg/L (median =0.0135 mg/L) but median values at North Harbour and Pakoka-Te Maari reached and slightly exceeded the guideline (0.015 and 0.016 mg/L, respectively). Higher concentrations of nitrogen parameters occur mostly in autumn and winter 2019 (May – October) with nitrate-nitrite nitrogen exceeding the guideline up to 6-fold at North Harbour. Median total phosphorus and dissolved reactive phosphorus concentrations remained under the guideline levels.

Nitrate-nitrite concentrations increased at the same time salinity decreased and were generally higher at the monitoring stations with less seawater impact. This points towards freshwater inputs as the source of inorganic nitrogen in the catchment.

Kamke (2021) concluded that, overall, the harbour system appears to be functioning well with current nutrient inputs. Signs of eutrophication such as increased chlorophyll a concentration or low dissolved oxygen were not observed. Water clarity was excellent thought the year and water turbidity was unlikely to inhibit phytoplankton growth.

4.3.2 Recreational water quality

Waikato Regional Council's recreational water quality monitoring programme focuses on water quality for human health by sampling for faecal indicator bacteria such as *E. coli*[19], enterococci[20] and faecal coliforms[21]. Historic data for Aotea Harbour is extremely limited, with data from a brief study of enterococci at one station (Aotea) in 1997, and then monitoring for enterococci and faecal coliforms every second season during 2001-2009. These historical results for the Aotea site were generally good.

Enterococci concentrations remained under guideline alert level with one exception in 2003. There were occasional exceedances for faecal coliform concentrations from 2003-2009 which led to exceedance of the 90th percentile guideline level (47 cfu/ml), however these results are likely to overestimate the level of microbial contamination[22]. Between 2019 and 2021, microbial parameters remained consistently below guideline values at all stations shown in Figure 12.

Based on these results, Kamke (2021) concludes that swimming and other recreational activities are not likely to be impacted. Historic faecal coliform data indicated impaired water quality for shellfish gathering; however, the current monitoring data from the estuarine water quality programme did not show any indication that water quality was unsuitable for shellfish gathering purposes with not a single

[19] As an indicator for freshwater

[20] As an indicator for saline waters

[21] As an indication of the suitability for shellfish gathering

[22] Because of a lack of data for Aotea, information from several years (i.e. from 1997 and 2001-2009) of monitoring were included in this statistic rather than a single year.

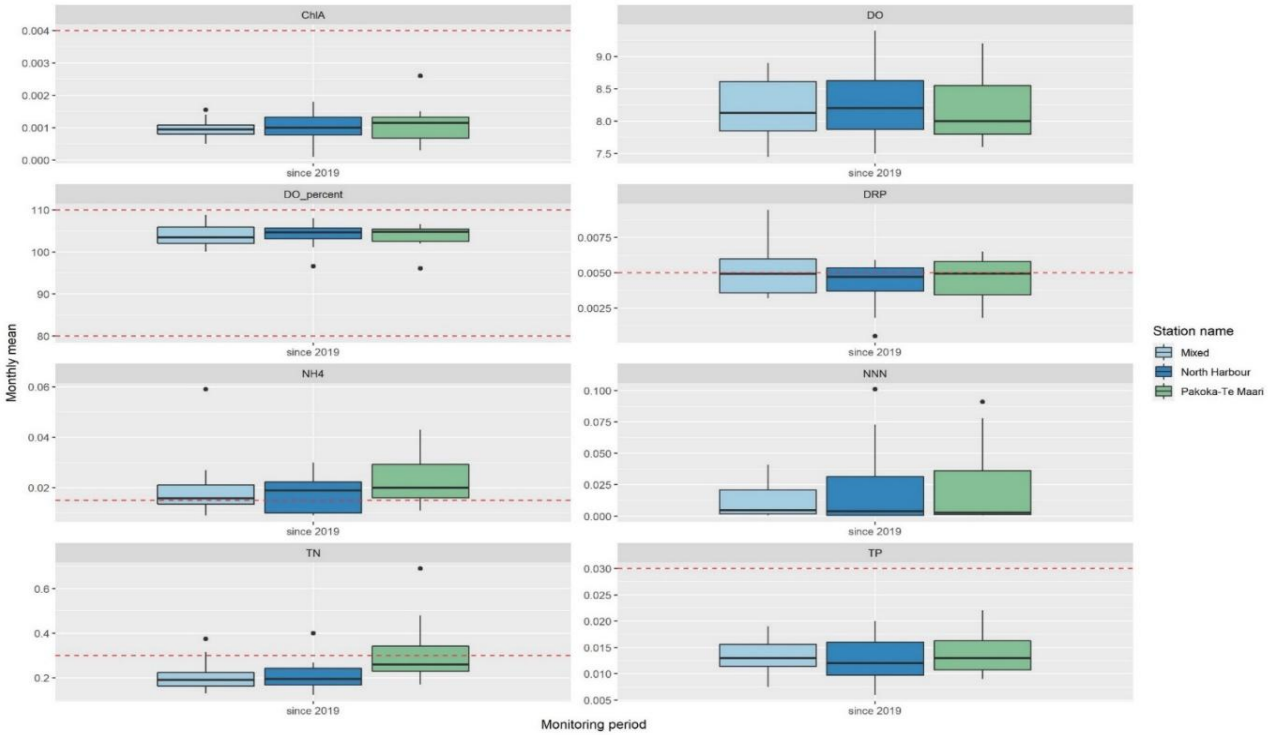

Figure 13. Aotea Harbour estuarine water quality monitoring data measured between 2019 and 2021. The box represents the interquartile range between the 25th and 75th percentiles (lower - upper border). The bold line represents the median. Vertical lines (whiskers) show the data range. Outliers (calculated at 1.5 interquartile range) are shown as black circles. Dashed red lines represent ANZECC guideline limits for each parameter (Kamke, 2021).

sample higher than 10 faecal coliforms/100 mL. As a consequence, shellfish gathering is very unlikely to be affected by microbial contamination at Aotea Harbour.

4.3.3 Summary – Coastal Water Quality

Recent estuarine water quality monitoring in Aotea harbour indicated a picture of overall good water quality and only slight pressure due to nutrients, sediments, and microbial contaminants. There was good mixing of the water column throughout the year. This decreases the likelihood of low oxygen in bottom waters putting pressure on sensitive organisms.

Overall estuarine water quality in Aotea Harbour appears to experience mild pressures from nutrients, which were most prominent in winter months and inner harbour sites. This is likely due to nutrient run off into the streams affecting the estuary.

It is unlikely that swimming, other recreational activities, or shellfish gathering are impacted by microbial contamination.

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

There is no formal water supply scheme for housing within the Aotea township and catchment. Water supply is via rainwater collection and storage.

4.4.2 Wastewater

Households within catchment rely on septic tank systems to manage wastewater. Careful management of septic systems are required to prevent pollution of groundwater and harbour waters and to allow for future growth.

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, and pose risks to public health and safety, property, or the ecological health of waterways. Stormwater is directed away from properties and roads and is discharged within the Aotea harbour. No information is available about the quality of stormwater discharge or the subsequent effects on the environment.

5 Biodiversity

5.1 Introduction

New Zealand was one of the last large land areas on earth to be settled by humans, and consequently evolution of our indigenous species happened in isolation of humans. This resulted in indigenous plants and animals that are vulnerable to introduced species. 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[23]. 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 Aotea catchment including within terrestrial, freshwater, and estuarine environments.

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).

A Significant Natural Areas (SNA) project has been in operation at Waikato Regional Council since 2006, with the aim to identify, rank, and determine the management requirements of sites of high biodiversity value in the region, largely focussing on terrestrial areas (Wildland Consultants Ltd., 2016). Figure 14 displays the SNA located within the Aotea Catchment. Across the catchment 16.9 % of the area has been identified as SNA (Wildland Consultants Ltd., 2016).

Waikato Regional Council identifies and prioritises[24] SNA in order to:

- protect natural heritage for future generations;
- protect sufficient habitats to provide habitat for threatened species and prevent extinction;
- link up or re-connect SNAs to improve their health; and
- fulfil its obligations under the Resource Management Act 1991[25].

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

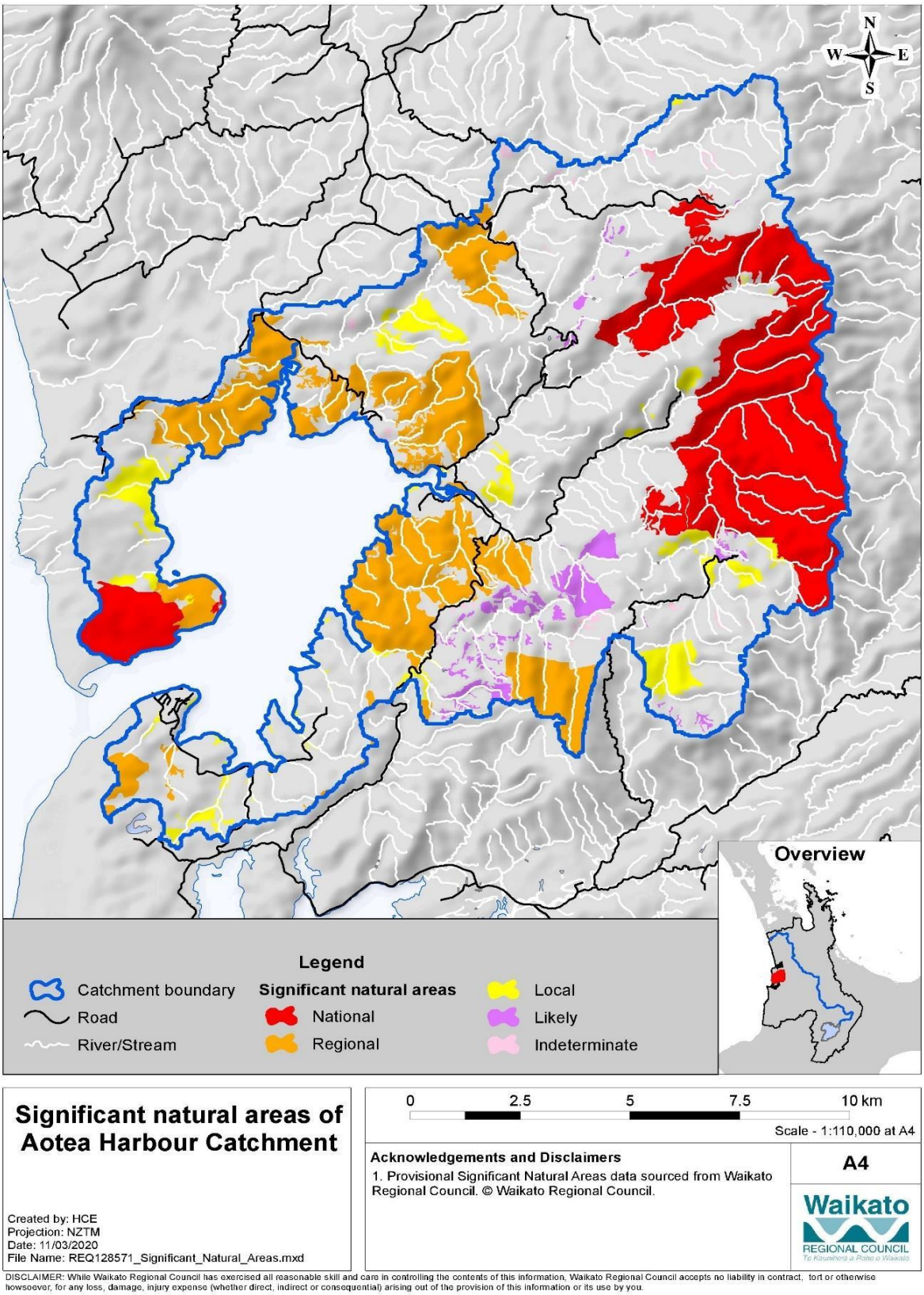

Figure 14. Significant natural areas in the Aotea catchment (Singleton, 2018).

5.3 Terrestrial vegetation

The original vegetation of the Kāwhia Ecological District (ED), which includes the Aotea catchment, and the extent of alteration that has occurred since human settlement is described in Harding (1997) and Wildland 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 tussockland, 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 catchment[26]. 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 extensive modification, the Aotea catchment retains some 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 further land use change and intensification, exotic species, and habitat modification.

Wildland Consultants Ltd. (2014) lists 26 nationally threatened 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 Kāwhia ED. Harding (1997) commented on the opportunity to protect important corridors of indigenous vegetation including areas of regenerating forest around the relatively-unmodified Aotea Harbour.

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[27].

Initial work has been undertaken to identify significant natural karst areas (Figure 15) 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.

A single surface karst feature, that incorporates Lake Disappear and surrounding areas, has been identified within the Aotea harbour catchment. The 53 hectare site is located to the south east of Bridal Veil Falls. It is the largest karst lake in New Zealand and the sites has naturally uncommon ecosystems including sinkholes, cliffs, scarps and tors. The lake forms in a degraded gully system that is mostly exotic pasture with some wetland species and scattered kahikatea around the margin of the site. Small patches of forest and scrub occur within the site, and much larger areas of native forest exist to the east and west (Waikato Regional Council, 2022). Some significant plant and animal species have been recorded within the broader locality and have potential to occur at the site, so the site is a high priority for further investigation and protection if required.

[26] At its southern limit of distribution

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

Figure 15. Map showing the surface karst sites that are significant in the Aotea catchment. (Source - [Management of karst landscapes in the Waikato (arcgis.com)])

5.5 Changes in terrestrial ecosystems within the Aotea catchment

As in many parts of New Zealand, the indigenous flora and fauna of the Aotea catchment has been greatly reduced. Despite this, the Aotea catchment contains a number of significant natural areas that contain important threatened species or rare habitat types.

Wildland Consultants Ltd. (2014) used the Land Environments of New Zealand (LENZ) classification system to assess the proportion of acutely and chronically threatened land environments within the Aotea catchment and reported that 34% of the Aotea Harbour catchment survey area was either Acutely Threatened or Chronically Threatened land environments. Threatened land environments were prevalent in North Harbour (95.9%) and South Harbour (89.2%) sub-catchments, which relate to the sand dune environments. Approximately one third of the land environments in the Pakoka (32.2%) and Okapu (38.3%) sub-catchments are Acutely or Chronically Threatened, whilst the Taparamapua (7.6%) and Te Maari (6%) sub-catchments contain less threatened land environments. Table 9 shows the extent (ha) of threatened land environment that was recorded in the Wildland Consultants Ltd. survey (2014).

Table 9. Extent (ha) of Land Environment Threat Classification categories within the Aotea Harbour catchment condition survey area. (Wildland Consultants Ltd., 2014)

Sub catchment	Acutely Threatened	Chronically Threatened	At Risk	Under - Protected	No Threat Category	Total
North Harbour	195	890	43		3	1,132
Okapu	60	703	90	155	981	1,988
Pakoka	243	795	566		1,617	3,220
South Harbour	399	965	162		4	1,530
Taparamapua	229	24	521	437	2,127	3,339
Te Maari	105	32	418	1,747	2,302	
Total	**1,231**	**3,409**	**1,800**	**592**	**6,479**	**13,510**

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 Aotea catchment is shown in Figure 16 and the codes used to identify ecosystem types are explained in Table 10. A map of estimated[29] current ecosystems in the catchment is shown in Figure 17. The area of coverage of each ecosystem type in the potential and estimated current ecosystems maps are also shown in Table 10 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. Natural wetland and dune land vegetation are heavily depleted within the Kāwhia ED, with dune vegetation most affected (displaced) by plantation forestry and invasive species. Swamp and Fen mosaic wetland appears depleted, but some of this is due to reclassification of wetlands. Almost all saline ecosystems, such as seagrass herbfields have been lost. These ecosystems now only comprise 1.36% of the catchment (reduced from 33%).

Lowland podocarp forest made up a small proportion of the original vegetation within the Kāwhia ED and most is still existing. A lot of the remaining rimu-tawa forest and montane conifer-broadleaved forest has been legally protected.

Through the mapping process there has been a large reduction in ecosystem type WF5 - Dune forest (Totara, kanuka, broadleaved forest) but this is due to a large percentage of this class being reclassed to coastal dunes, pasture and manuka.

Overall, the Aotea 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.

[28] *Based on the WRC biodiversity inventory layer*

[29] The draft biodiversity inventory has not been ground-truthed and is therefore indicative only.

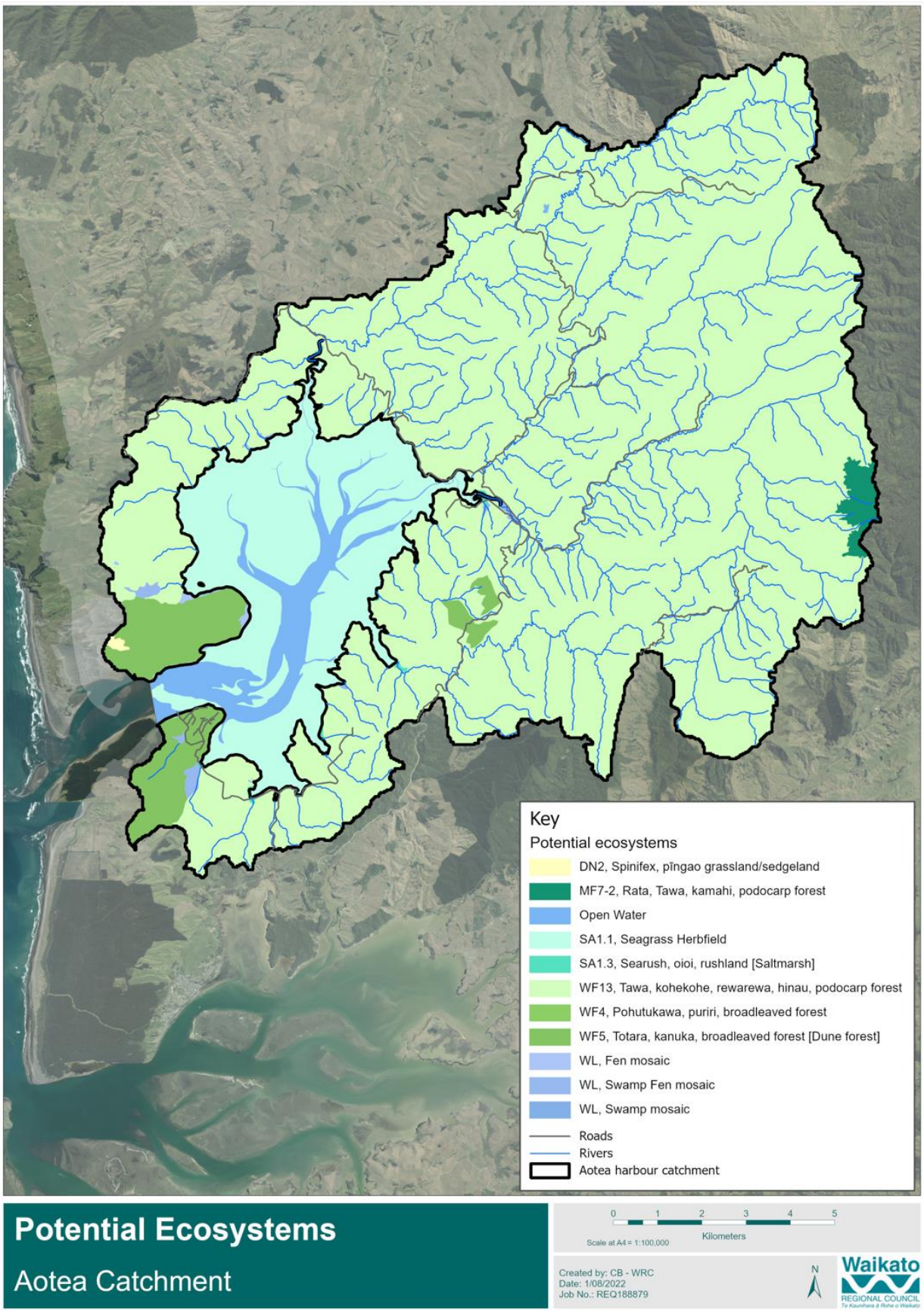

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Figure 16. Potential ecosystems in the Aotea catchment. Codes are explained in Table 10.

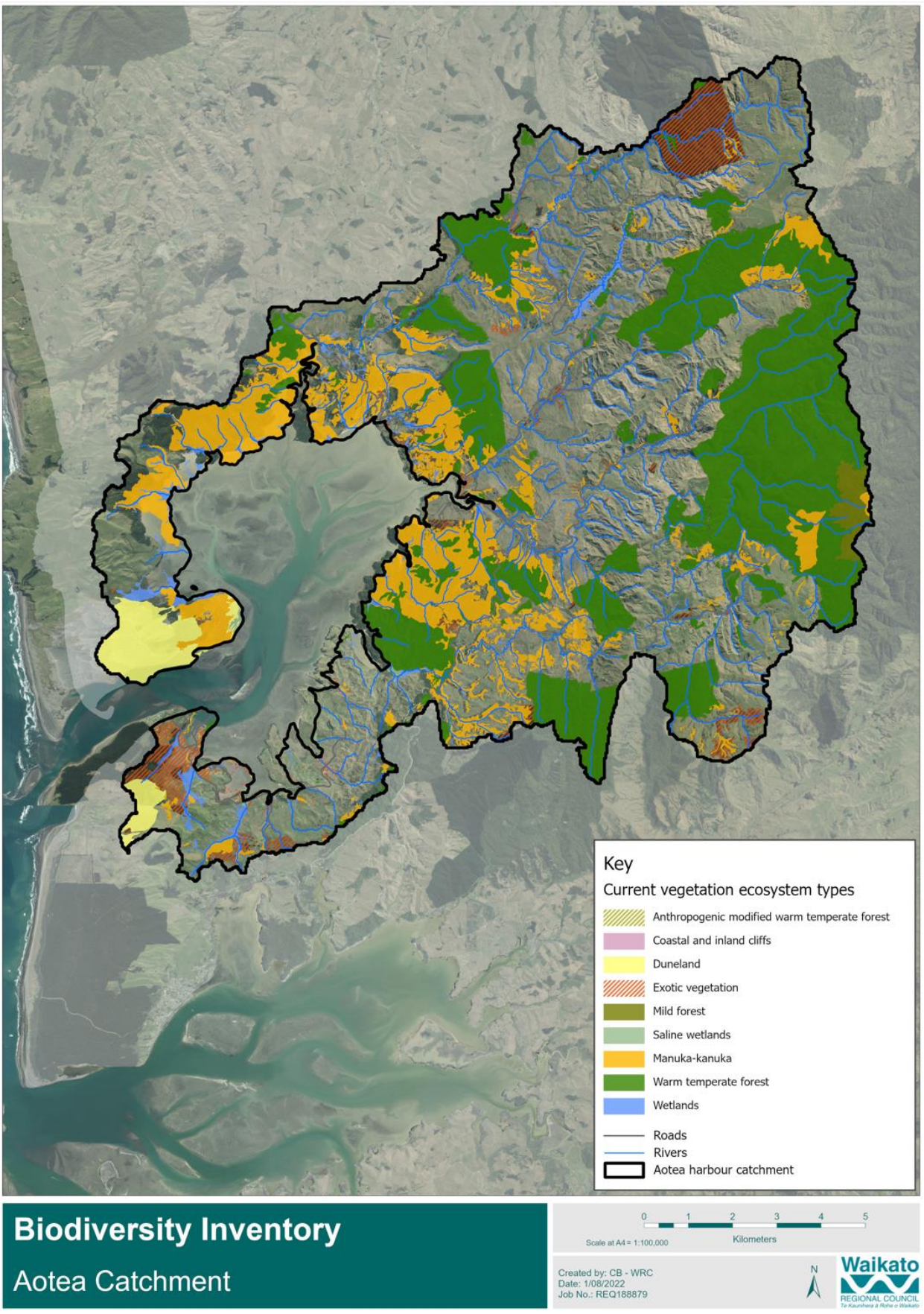

Figure 17. Draft biodiversity inventory for the Aotea catchment.

Table 10. 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)		0.33	
AWF3	Riparian Forest – Adv Sec Riparian Forest - totara, kanuka, kahikatea		0.13	
Cliffs (CL)				
CL1	Pohutukawa treeland/flaxland/rockland		3.41	
Active coastal sand dunes (DN)				
DN2	Spinifex, pingao grassland/sedgeland	11.72	2.10	17.89
DN2/5	Coastal Sand Dunes Mosaic		146.57	
Exotic (E)				
EF-FH	Forest Harvested		3.57	
EF-OEF	Other Exotic Forest		23.10	
EF-PFCC	Pine Forest - Closed Canopy		452.30	
ES-DHW	Deciduous Hardwoods		17.16	
ES-EGH	Exotic grassland, herbfield, rushland		29.89	
ES-GB	Gorse, Broom, pampas and woolly nightshade		113.79	
Mild Forest (MF)				
MF7-2	Rata, Tawa, kamahi, podocarp forest	126.64	118.94	93.92
Saline (SA)				
SA1.1	Seagrass Herbfield	33.06	1.36	4.11
SA1.3	Searush, oioi, rushland [Saltmarsh]	40.79	58.59	143.64
SA1.6	Saltmarsh, ribbonwood, ngaio, akeake scrub		0.25	
Vegetation Succession (VS)				
VS16	Restoration/Revegetation – mixed native plantings		9.87	
VS17	Mixed native & exotic shrubland		22.48	
VS2	Kanuka scrub/forest		145.55	
VS2.1	Advanced regenerating podocarp with kanuka		8.98	
VS3	Manuka-Kanuka		1785.19	
VS3.1	Adv sec with regen conifers through Manuka-kanuka mosaic		14.18	
VS4	Manuka		6.22	
VS5	Broadleaved species scrub/forest mosaic/treefern scrub		237.63	
VS5.1	Adv sec broadleaved forest - most kamahi-dominated		76.10	
VS5.2	Tree fernland		98.10	
Warm forest (WF)				
WF13	Tawa, kohekohe, rewarewa, hinau, podocarp forest	15808.24	4099.50	25.93
WF4	Pohutukawa, puriri, broadleaved forest	1.71	7.37	430.74
WF4.1	Coastal/semi coastal, little or no Pohutukawa		160.09	
WF5	Totara, kanuka, broadleaved forest [Dune forest]	792.54	0.00	0.00
WF7-3	Kahikatea, puriri forest		4.03	
WF8	Kahikatea, pukatea forest		18.07	
WF8/WL	Kahikatea, pukatea forest and Swamp mosaic		11.39	

Wetlands (WL)				
WL	Herbaceous Freshwater wetland vegetation		47.54	
WL-FM	Fen mosaic	15.26	12.58	82.43
WL-SFM	Swamp/Fen mosaic	54.84	4.87	8.88
WL-SM	Swamp mosaic	1.62	208.38	12894.73
WL19	Raupō reedland		0.98	
Other	Other		246.40	

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

5.6 Rivers and streams

Biodiversity river prioritisation for the Waikato region identified the highest value rivers most representative of a particular river type in the 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 (Leathwick and Julian, 2009).

Rivers and streams identified as significant natural areas within the Aotea catchment include (Waikato Regional Council, 2016b):

- Waitapu Stream
- Papatapu bush
- Kainamunamu Stream
- Te Kopua Stream
- Taparamapua Stream
- Makomako Stream and its tributaries.

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

Lake Disappear in the Aotea catchment, at a length of 2km (max) is the largest known karst polje lake[30] in the North Island, and the largest ephemeral karst lake in New Zealand (Figure 18). These types of lakes form in large hollows that form where water[31] has dissolved the carbonate rocks in the surrounding limestone landscape (Lowe and Green, 1992).

30 Karst lakes are also known as 'solution lakes'

31 from rainfall and subsurface streams

Figure 18. Lake Disappear when empty and full, viewed from Kawhia Rd (July 2008) (Source Wikipedia 2022 Lake Disappear - Lake Disappear - Wikipedia)

Lake Disappear exists in a valley that was once a podocarp forest but is now mostly farmland with some remnant kahikatea and wetland sedges. The lake temporarily fills to a depth of about 15m after heavy rainfall. In such conditions inflows exceed the rate of discharge underground through a limestone sinkhole at the southwest end of the lake. Water reportedly re-emerges in the Pakihi Stream due south, disappears for another 200 metres, then joins Te Maari Stream and finally reaches Aotea Harbour.

Waikato Regional Council prioritised and ranked known lake ecoystems in 2009. Lake Disappear was recognised as being a rare ecosystem type but was unable to be ranked because of insufficient information (Wildland Consultant Ltds., 2011).

5.8 Aotea Harbour

Aotea harbour is the smallest of three drowned valley harbours on the Waikato's west coast covering c.3,100 hectares. It is a shallow estuarine harbour enclosed by a large sand spit and extensive dune system and it contains five bays.

The harbour is well flushed with a relatively low residence time, and around 81% of the area is exposed at low tide. The extensive intertidal sandflat and mudflat areas provide habitat for diverse and abundant benthic communities, including sea grass and shellfish (Singleton, 2018).

The coastal waters and margins of Aotea Harbour (Figure 19) have been assessed as having Outstanding Natural Character. 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 (Boffa Miskell Ltd., 2016).

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

- extensive sandspit and sand dune features adjoining the harbour;
- extensive eel grass communities;
- the presence of (resident and visiting) rare and threatened wading and coastal bird species;
- the presence of Maui dolphin.

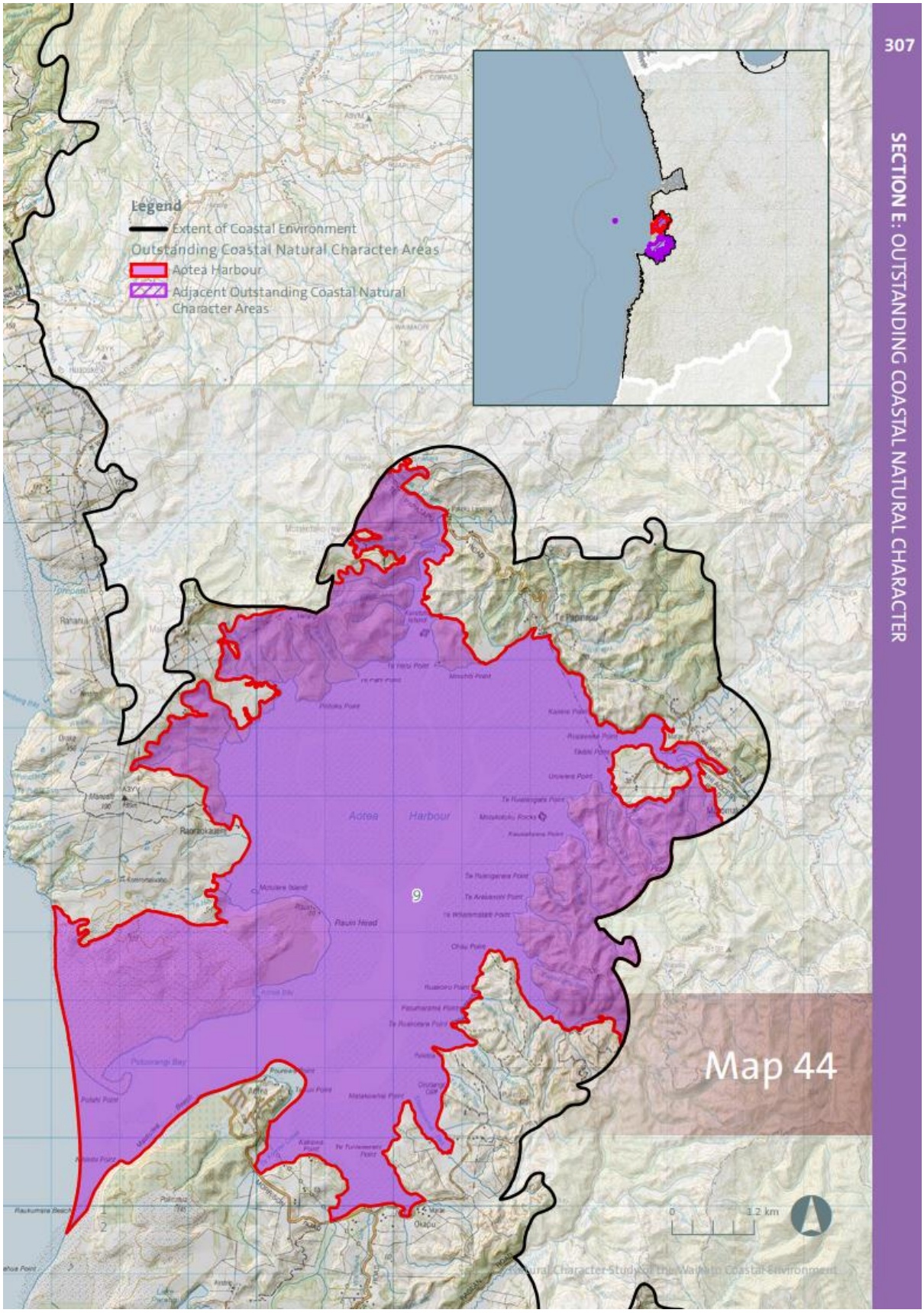

Figure 19. Outstanding natural character – Aotea Harbour (Boffa Miskell Ltd., 2016)

5.9 Shorebirds in Aotea Harbour

Aotea harbour provides important habitat for a range of international and local migratory waterfowl, and a variety of resident species. Bird counts have been undertaken annually at Aotea and Kāwhia harbours since 1976 by the Ornithological Society of New Zealand (now Birds New Zealand).

Aotea harbour is one of the top 19 shorebird wintering sites in New Zealand that are nationally important[32] for indigenous and international shorebirds including pied oystercatchers[33], banded dotterel, pied stilts[34], and Arctic migrants[35] (Dowding and Moore, 2006). Rare and threatened wetland birds also occur within the saltmarsh and reed vegetation of the harbour including banded rail, Australasian bittern (matuku) and North Island fernbird.

The harbour also 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. Geese were first detected in Aotea harbour in 2010 and have since increased but remain at relatively low numbers compared to Raglan and Kāwhia harbours (Smith, 2019). There is widespread concern about the impacts of Canada goose and black swan populations on the ecology of the West Coast harbours as a result of their feeding behaviour on seagrass communities. There is also some concern about their indirect impacts on sea grass through trampling, increased turbidity and eutrophication via deposition of faecal matter, and wider ecological effects including impacts on indigenous birds[36], and dispersal of undesirable plants and animals (Smith, 2019).

5.10 Aquatic fauna in the Aotea catchment

5.10.1 Shellfish in Aotea Harbour

Shellfish perform important ecosystem services in estuaries. They form an important component of shorebird and fish diets and are a significant source of mahinga kai for mana whenua. The presence of shellfish can have a profound impact on water quality as they feed by pumping water across their gills and filtering out food particles. The removal of organic particles from the water column is likely to improve water clarity and provide for greater light availability and increased primary production.

Aotea harbour is known to support significant shellfish populations. Intertidal shellfish surveys[37] (with a focus on cockle and pipi beds) have been carried out in Aotea Harbour in 2005 (Walshe and Akroyd, 2006), 2009 and 2010 (Pawley, 2011) and February 2015.

An early Ministry of Fisheries study estimated the cockle population in Aotea harbour to be around 30.4 million (Walshe et al., 2005). Berkenbusch and Neubauer (2016) sampled cockles within Aotea Harbour and estimated a total population of 34.99 million cockles with a mean population density of 356 cockles per square metre.

In 2008, 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,

[32] Meeting the criteria for national importance of supporting 1% or more of a national population)

[33] Aotea is a top 10 site for this species

[34] Aotea is important at the 1% level or higher for these species

[35] Aotea is used by 1000 or more Arctic migrants

[36] including disease risk and competition

[37] commissioned by the Ministry of Primary Industries

including seagrass[38]. Two areas of Aotea Harbour were sampled during the study. In these areas, cockles were the most numerous, but wedge shells were slightly more widespread. Pipi were recorded in much smaller numbers in very restricted locations. Cockle and wedge shell density was highest in substrates with sand rather than mud. Cockle density was influenced by the presence of seagrass and sediment type. Wedge shell abundance was not related to the presence of seagrass in Aotea Harbour (Hillock and Rowan, 2011).

The information on the sediment characteristics and abundance and distribution of cockles and wedgeshells in Aotea harbour is a good baseline for future comparisons. Studies have shown that cockles and wedge shells may tolerate short term exposure to pulses of suspended sediment, but that sustained exposure is problematic. Terrigenous sediment (eroded from the land) is known to be more difficult for cockles to process than re-suspended marine sediments (Bouma, 2016).

5.10.2 Freshwater fish and macroinvertebrates

The Regional Council does not have any long-term monitoring sites within the Aotea catchment and so data from Kāwhia catchment has been used to develop a picture of ecological health of rivers due to the similarities of the catchments in terms of biophysical properties, land use and land cover. The Ecological Monitoring (REMS) Programme measures macroinvertebrate and stream habitat at four Kāwhia sites annually – within the Awaroa River, and Mangahoanga, Omanawa and Waikuku Streams.

Results indicate that the state of the four river and stream sites is assessed as excellent to good based on their macroinvertebrate community index. Trends are mostly improving, indicating little risk of negative change. Results are available from the LAWA website https://www.lawa.org.nz, and are summarised in Waikato Regional Council (2024).

Most 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 species have suffered substantial population declines as a result of habitat modification and loss. Instream habitat for native fish species can be affected by a range of factors, including:

- Sedimentation can reduce water quality, the amount of available habitat[39], and smother 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.
- Fish Passage through the catchment can be severely restricted by inappropriate structures (including culverts and fords). National guidelines have been developed for the design of instream infrastructure to provide for fish passage[40]
- Fish are very sensitive to changes in river and stream water quality, including temperature[41]. Instream temperatures are directly related to the amount of riparian vegetation/shading that is available. Riparian vegetation is a key component of restoration projects that have considerable benefits for freshwater fish and invertebrates.

[38] seagrass (*Zostera* sp.) was the most abundant plant in both harbours

[39] Including by filling interstitial spaces on the stream bed

[40] www.niwa.co.nz/static/web/freshwater-and-estuaries/NZ-FishPassageGuidelines-upto4m-NIWA-DOC-NZFPAG.pdf

[41] which directly affects oxygen saturation levels, and the toxicity of a range of contaminants

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 Councils existing Regional Ecological Monitoring of Streams (REMS) programme in 2011/12 (David et al., 2016). This has involved establishing a network of 160 sites across the region that are fished at least once every 3 years[42]. None of these sites occur in the Aotea harbour catchment.

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,* that play an important functional role within ecosystems[43], and are recognised as a cultural keystone species[44]. However, all three species have been classified as "Nationally Vulnerable" or "At Risk" under New Zealand's threat classification system (Grainger et al., 2014).

Two of these mussel species *(Echyridella menziesii*, *E.aucklandica)* are known to occur within the Aotea catchment. To monitor freshwater mussel populations, Waikato Regional Council has developed a standardised protocol for monitoring in wadeable streams and rivers (Melchior et al., 2023), which has been applied in five catchments of the Waikato region between 2013-2017. Three sites occur within the Aotea catchment (in the Makomako, Matahahaia, and Pakoka Streams).

The results of this work indicates that freshwater mussels generally occur in low densities within the region, with a few exceptions where dense populations occur. Several streams flowing into Whāingaroa, Kawhia, and Aotea harbours are known to support both species, including the Pakoka Stream. One species of freshwater mussels (*E.menziesii*) occurred in the Makomako and Matahahaia streams.

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 ageing populations for both species with little sign of juvenile recruitment.

5.11 Aquatic flora in the Aotea Catchment

5.11.1 Wetland Vegetation

Wetlands are biologically rich and important features within the Aotea catchment[45] that are primarily controlled by water. They 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 NZ, wetlands have been reduced and lost from the Aotea 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 between 1992 – 2005. This is considerably

[42] With the exception of 15 reference sites that are visited annually.

[43] They have the ability to filter large amounts of sediment and inorganic compounds as well as particulate organic material and phytoplankton. Because they feed across multiple trophic levels, they have both direct and indirect impacts on sediment bioturbation, bio-deposits, food availability and nutrient cycling (Caitlin et al. *in prep*).

[44] because of their cultural importance (as a taonga species and a source of mahinga kai) for Maori

[45] Wetlands can be in freshwater or estuarine environments or in areas where both combine.

[46] This does not include wetlands that have been only partially drained or altered

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

The Raoraokauere wetland (in the North Harbour sub-catchment) has been identified as significant within the Aotea catchment and Graeme (2005) commented on the importance of the intact estuarine-freshwater wetland sequences occur on the western side of Aotea harbour, southwest of Pakoka landing. These areas include freshwater swamp forest of various sizes, and extensive coastal forest.

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.

A relatively high proportion (Table 11) of the Aotea Harbour coastal margin has a cover of native vegetation (69.4%) or exotic vegetation (11%), reflecting the substantial areas of coastal indigenous forest or scrub present, especially in the North Harbour and Okapu sub-catchments (Wildland Consultants Ltd., 2014).

The estuarine vegetation of Aotea harbour was surveyed in 2005 and 2012 (Graeme, 2005 and 2014) and a stocktake completed by Bouma in 2016 (Figure 21). The harbour includes mangroves, salt marshes, seagrass, sea meadows and weed communities as discussed below.

Mangroves (*Avicennia marina* var. *resinifera*) occur sparsely within Aotea harbour. Small numbers of mature trees occur usually near the head of sheltered arms. Some seedlings were noted in association with these trees.

Saltmarshes are composed of mixtures of low-growing herbs (sea meadows)[47], rushes[48] and sedges[49]. Graeme (2014) observed that rush/sedgeland[50] is the most predominant vegetation community around

[47] e.g. glasswort, sea primrose

[48] e.g. sea rush

[49] e.g. oioi, knobby clubrush

[50] sea rush, oioi and three square

the harbour edge. .

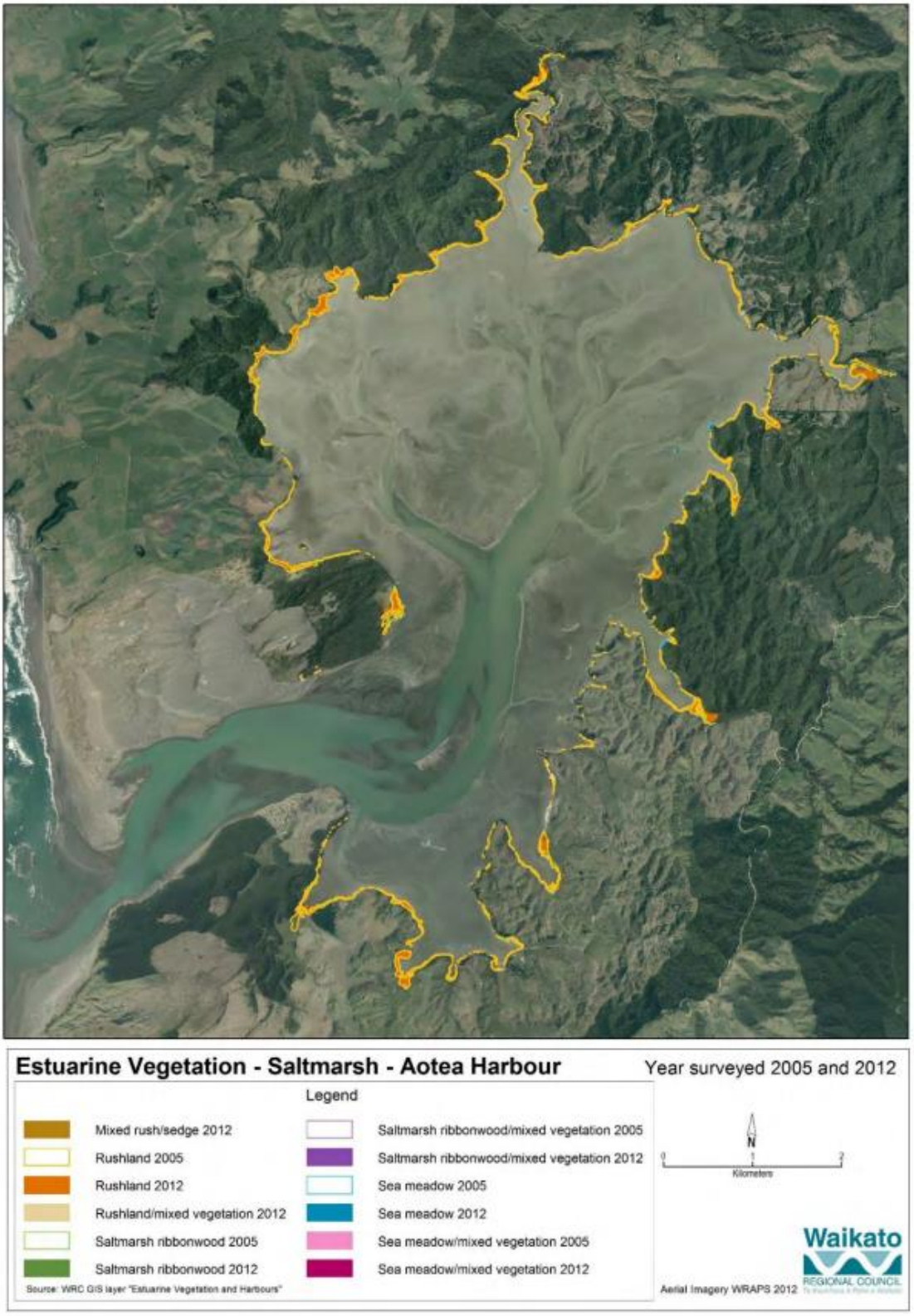

Figure 2122 shows the saltmarsh extent within the Aotea harbour.

Bands of saltmarsh ribbonwood occurred all around the harbour, particularly where stream flats have not been drained or filled. Saltmarsh ribbonwood was predominant in areas south of Motutere Island, south

of Puketutu Stream, the head of the Pakoka River, Makomako Stream bay, the mouth of the Waiteika Stream and at Matakowhai Bay.

Sea meadow communities were widespread but were restricted to small and discrete patches.

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. Seagrass beds occur extensively across the middle tidal regions (Figure 20) of Aotea harbour (Graeme, 2014; Bouma, 2016).

Weeds and inappropriate land use were identified by Graeme (2014) as the main issues affecting the health of estuarine vegetation within Aotea Harbour at that time. Specific examples included:

- Unfenced farmland adjacent to streams, freshwater wetlands and harbour margins;
- Lack of fencing around remnant coastal forest trees (i.e. Pohutukawa) to assist with regeneration around the coastal margin;
- Free-ranging goats were an issue for the regeneration of native forest and riparian areas around the coastal edge.
- Stock access to the harbour was noted in a few areas causing damage to vegetation health and increasing sediment and water quality disturbance.

Spartina and saltwater paspalum are two key invasive exotic species that are threatening the health and integrity of estuarine vegetation. An active control programme, led by DOC, is underway for spartina, but has not yet been established for saltwater paspalum. Saltwater paspalum is considered a greater threat to estuarine communities than spartina as a result of its competitiveness.

Table 11. Coastal margin vegetation condition in the Aotea Harbour, based on the extent (length in meters) of three broad vegetation classes (from Wildland Consultants Ltd., 2014).

Sub catchment	Native (m)	Exotic (m)	Grass (m)	Total (m)
North Harbour	4,556 (91.5%)	0 (0.0%	422 (8.5%)	4,978
Okapu	8,280 (97.1%)	115 (1.3%)	132 (1.5%)	8,526
Pakoka	3,804 (64.9%)	1,681 (28.7%)	374 (6.4%)	5,859
South Harbour	9,553 (53.2%)	2,527 (14.1%)	5,886 (32.8%)	17,966
Taparamapua	1,101 (55.3%)	0 (0.0%)	889 (44.7%)	1,990
Te Maari	N/A	N/A	N/A	N/A
Total	**27,294 (69.4%)**	**4,323 (11.0%)**	**7,703 (19.6%)**	**39,321**

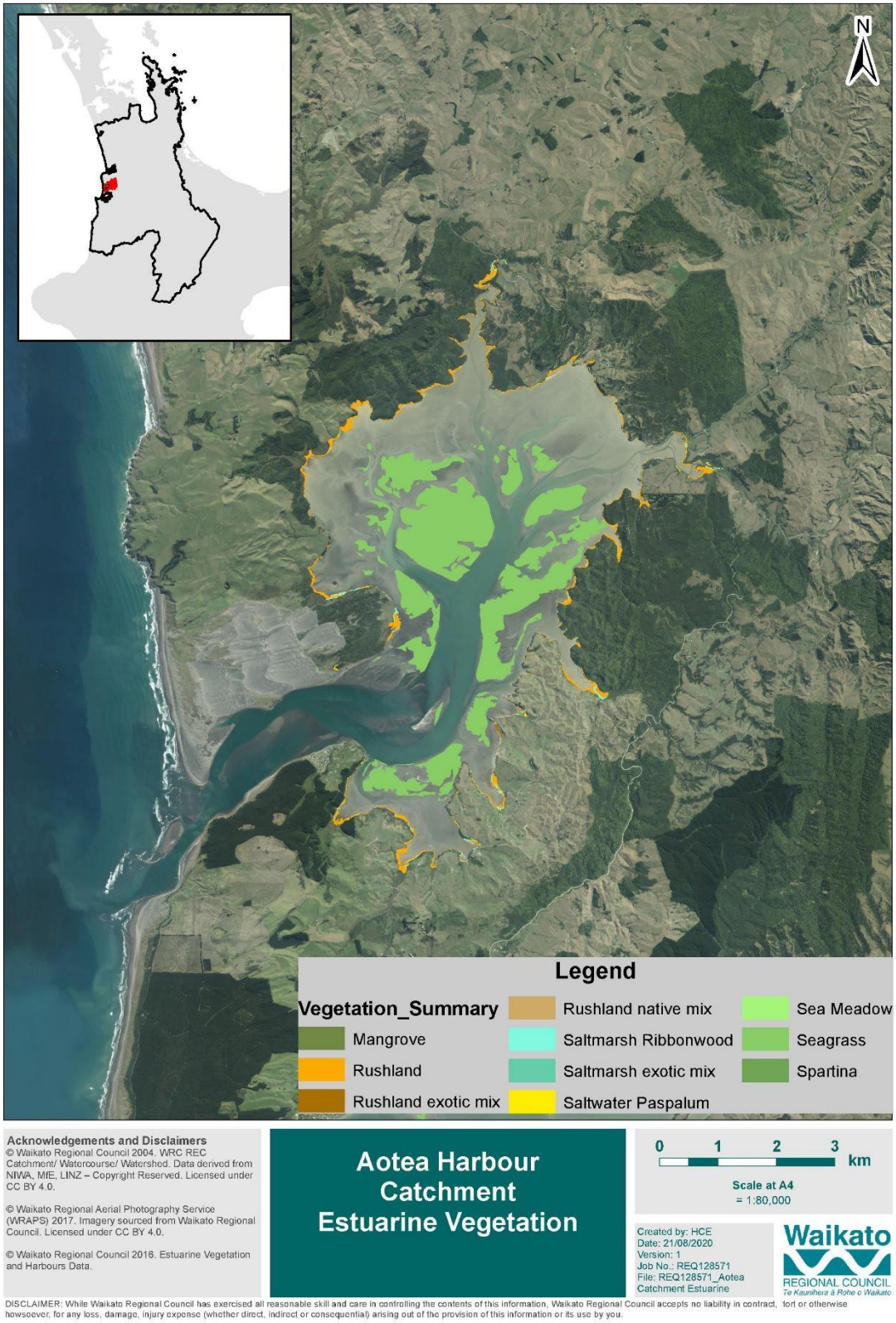

Figure 20. Estuarine vegetation distribution in Aotea Harbour. Source: Bouma (2016).

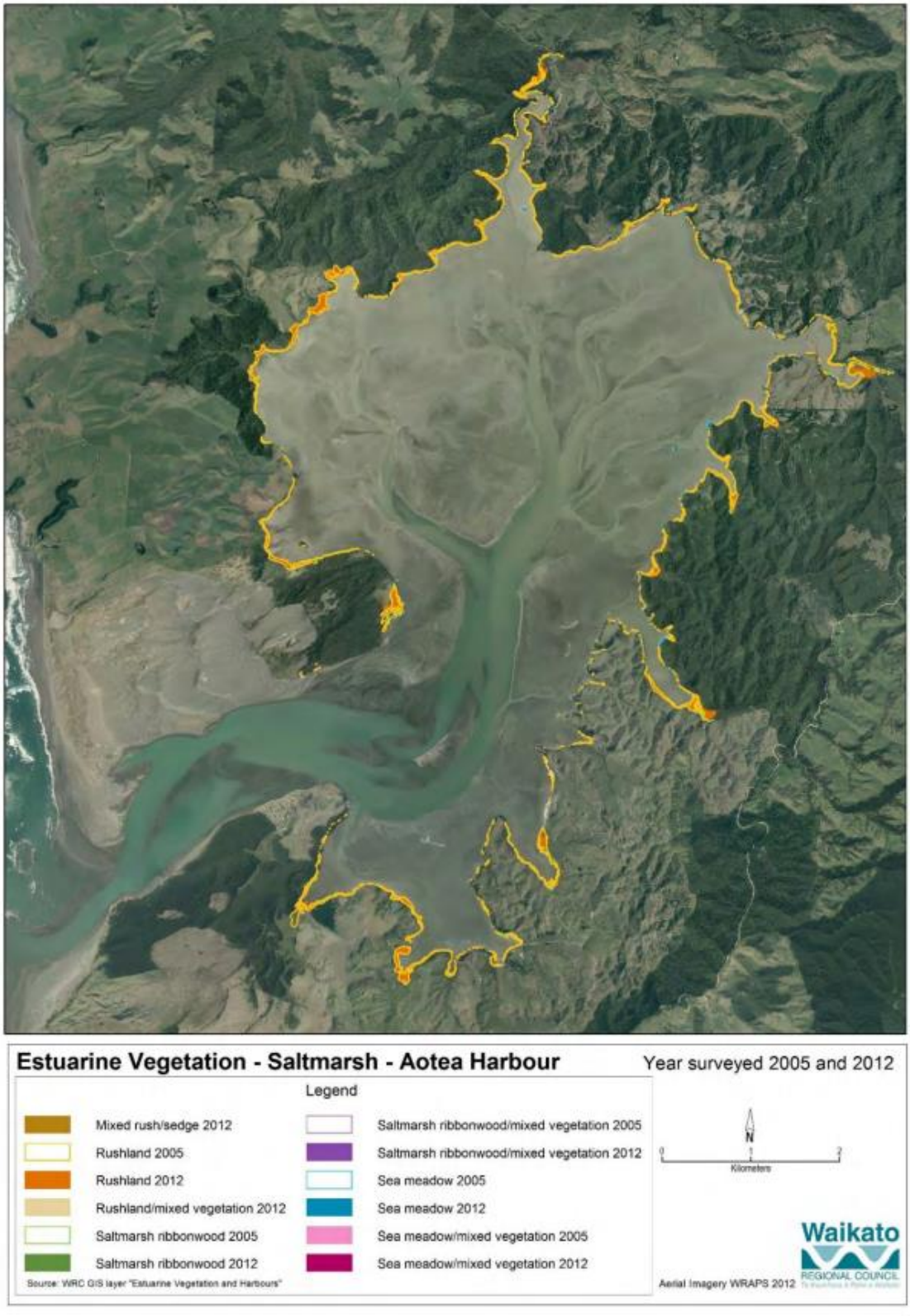

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Figure 21. Saltmarsh distribution in Aotea Harbour. Source: Bouma (2016).

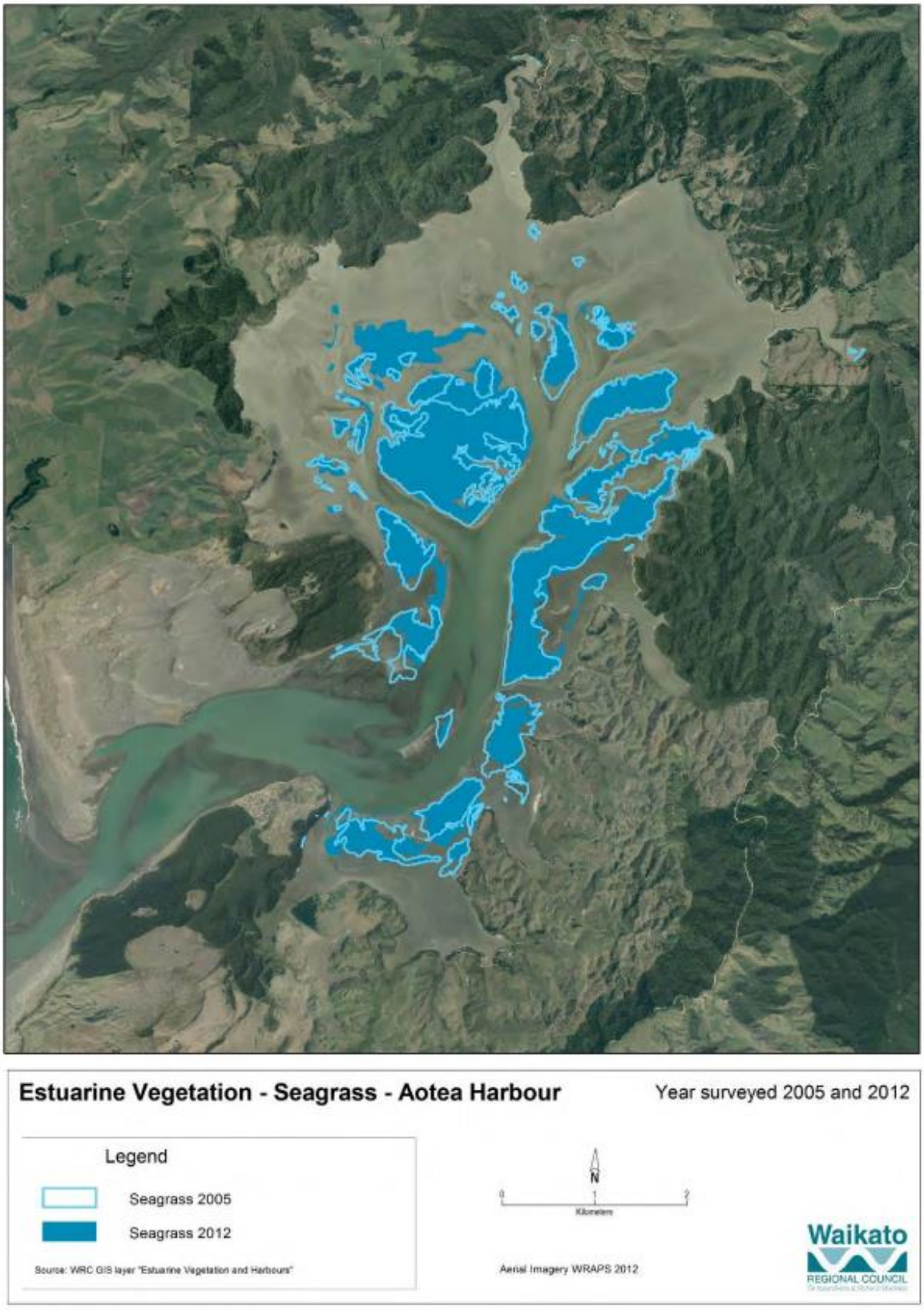

Figure 22. Seagrass distribution in Aotea Harbour. Source: Bouma (2016).

6 Biosecurity

6.1 Introduction

Many of New Zealand's indigenous species evolved and once thrived without any native predators. However, many introduced pests[51] 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 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:

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

In this section, information on a range of pest plants and animals that threaten the Aotea Harbour catchment is provided.

6.1.1 Pest Animals

Priority possum control areas (PPCAs) are areas of land that have been identified by the Waikato Regional Council as needing possum control to:

- protect and enhance biodiversity
- improve the stability of catchments
- enhance farm production
- maintain the gains of previous or existing possum control

Within the Aotea catchment, Waikato Regional Council undertakes possum (*Trichosurus vulpecula*) control within two PPCAs on a three yearly basis (see map in Figure 23), which encompass parts of the following two areas:

- Mt Pirongia North buffer
- Mt Pirongia West buffer

These areas adjoin conservation land on the Pirongia mountain 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.

Feral goats (*Capra hircus*) are also a significant issue within the Aotea harbour catchment. Wildland Consultants Ltd. (2014) recommended that the management of goats and possums be considered in future catchment management processes to help secure the ecosystem services provided by indigenous forest and scrub. Waikato Regional Council currently co-funds the goat control work that DOC undertakes

[51] 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.

in the Pirongia area. Figure 23 shows the scale of the control areas undertaken by Waikato Regional Council for possums and goats.

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:

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

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 used Aotea, Raglan and Kawhia estuaries during the 2018 moult season survey.

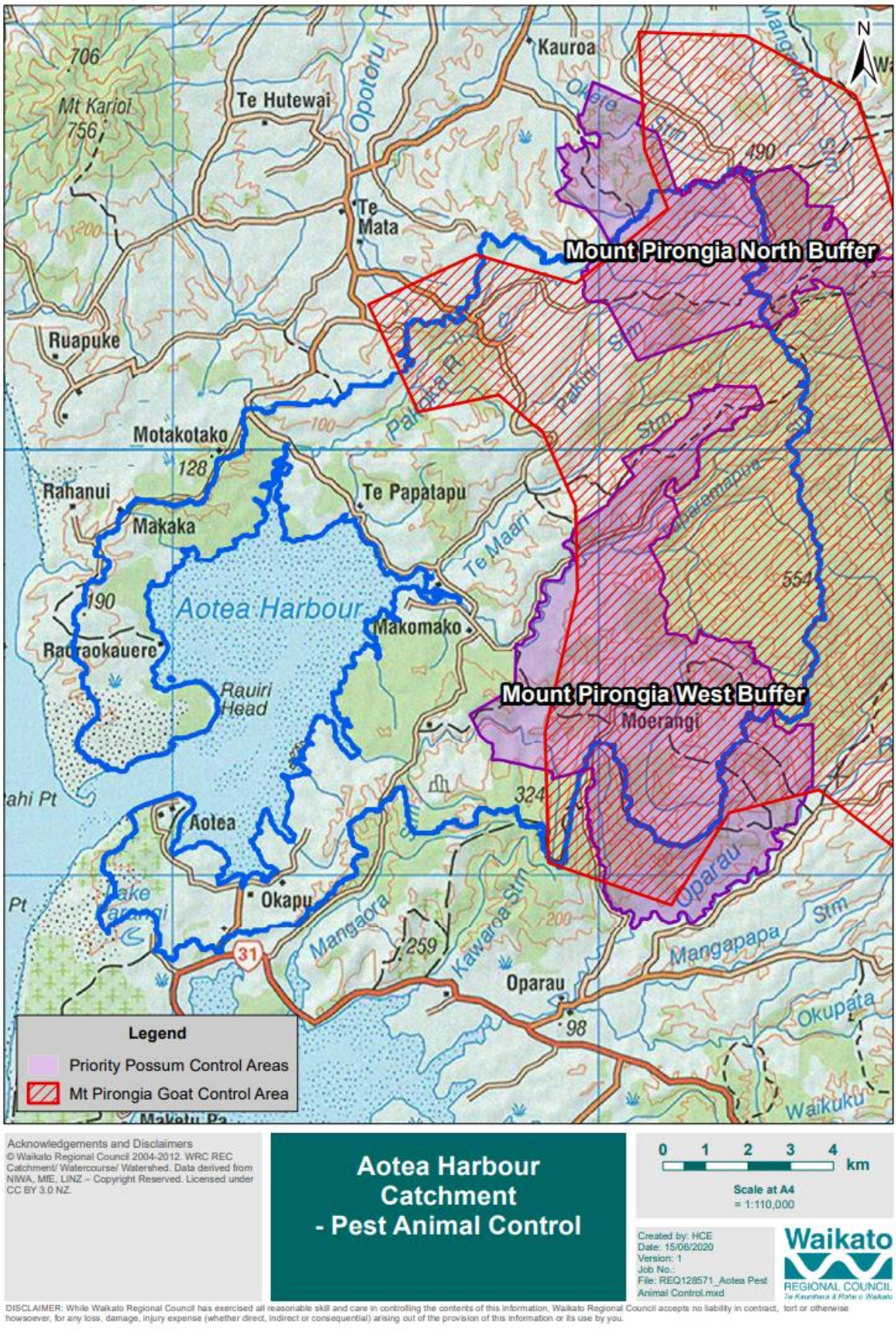

Figure 23. Pest control areas within the Aotea Catchment

6.1.2 Pest Plants

The harbour mouths, and debris collection points along the coast are considered to be most vulnerable to new infestations of alligator weed, sea spurge and yellow flag iris that colonise from the open coast. 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. These areas are therefore recognised as requiring surveillance, although there is no consistent ongoing weed surveillance programme for the West Coast harbours. Waikato Regional Council is the lead agency for the management of boneseed.

In 2012, sea spurge, (Euphorbia *paralias)* was found in the dunes north of Aotea, but no additional plants have been found in subsequent surveys (reported in Graeme 2014).

In April-May 2018 visual weed surveys were undertaken at specific sites around the mouths of Kāwhia, Aotea and Whāingaroa 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, simlas, wild ginger, climbing asparagus and bamboo grass were found. Saltwater paspalum, marram, boxthorn, ice plant, agapanthus and yucca were also located in estuarine and coastal planting areas (Graeme[52], unpubl. 2018).

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

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

Spartina and saltwater paspalum are two key invasive exotic species that are threatening the health and integrity of Waikato estuaries. They had been identified as the most important estuarine weeds in Aotea harbour that pose the greatest ecological risks. The distribution of these species was surveyed in 2005 and 2012 and is shown in Figure 24. Spartina had decreased significantly in coverage due to the control programme undertaken by the Department of Conservation. Graeme (2005 & 2014) considered the progress of DOC's eradication programme and concluded that eradication was feasible, and as of 2024 it is close to being achieved (D. Embling, pers. comm.).

Saltwater paspalum (*Paspalum vaginatum*), another weedy grass, was showing an increasing trend in coverage within Aotea (Figure 25) when last surveyed (Graeme 2014). The biology and weed characteristics of saltwater paspalum in New Zealand were reviewed by Graeme and Kendal (2001). It is of particular concern in estuaries because of its smothering habit and its wide habitat range. It will grow amongst and compete with all estuarine vegetation communities except sea grass and will colonise open mudflats. It can climb over vegetation and form dense beds, easily smothering sea meadow, saltmarsh ribbonwood, rushland and even short mangrove communities. Saltwater paspalum generally excludes

[52] Plant pest surveillance monitoring in West Coast harbours West_Coast_weed_surveillance_report_2018.pdf (wairc.govt.nz)

burrowing fauna, reduces access to bird feeding and roosting sites and alters fish spawning and feeding grounds. At the upstream saltwater limit, saltwater paspalum grows amongst freshwater riparian vegetation and often meets its freshwater invasive relative, Mercer grass (*Paspalum distichum*). 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.

In a sub-regional ecological prioritisation, Aotea harbour has been identified as the highest scoring west coast estuary for saltwater paspalum control (Graeme and Kendal, 2014). As of 2024, a dedicated control programme has not commenced (D. Embling, pers. comm).

Graeme (2014) observed that the disturbance of estuarine vegetation by stock, feral animals, drainage works, tracking, and roading, increases the vulnerability of these areas to weed invasion and persistence, and also exacerbates the spread of saltwater paspalum by breaking off fragments which can then float away to infest new sites.

A 2014 Aotea catchment survey by Wildland Consultants Ltd. included recording of pest plants identified in the Waikato Pest Management Strategy (RPMS). As shown in Table 12, fifty-five occurrences were recorded during the study. However, it is likely that not all infestations and species present were detected, due to the size of the study area, time constraints, and the fact that pest plants were not a "must record" feature.

Figure 24. Some short spartina beside a clump of oioi. Also note the mangrove seedling in the oioi. (Graeme, 2014)

Table 12. Infestations of Regional Pest Management Stratgey pest plant species recorded in the 2014 Aotea Harbour catchment condition survey area (Wildland Consultants Ltd., 2014).

Species	**Pakoka**	**South Harbour**	**Taparamapua**	**Te Maari**	**Total**
Climbing asparagus (*Asparagus scandens*)	2	2			
Mexican daisy (*Erigeron karvinskianus*)	1	1			
Old man's beard (*Clematis vitalba*)	1	1			
Pampas (*Cortaderia jubata* and *C. selloana*, and cultivars)	3	7	11	13	34
Privet (*Ligustrum* spp.)	3	4	7		
Wild ginger (Kahili ginger *Hedychium gardnerianum*, yellow ginger *H.flavescens*)	1	1			
Willow (grey *Salix cinerea*; crack *Salix fragilis*)	3	1	4	8	
Total	**4**	**12**	**16**	**23**	**55**

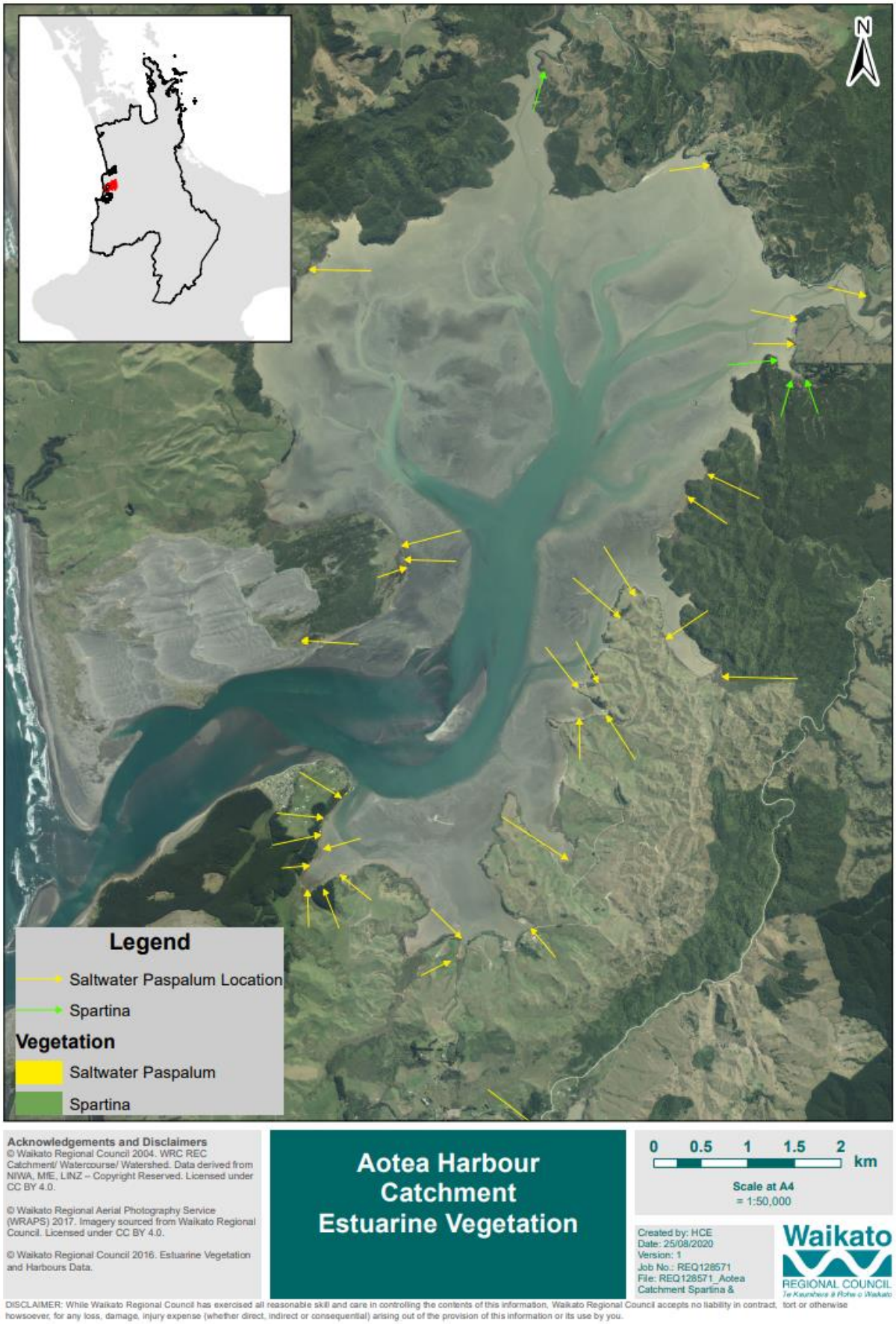

Figure 25.Estuarine Vegetation in Aotea Harbour catchment 2015. Source: Bouma (2016).

6.1.3 Pathogenic Pests

Kauri dieback disease[53] was discovered in 2009 and is threatening the well-being of kauri within New Zealand. Kauri trees 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 southern limit of its distribution.

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

- fencing out stock
- maintaining good hygiene (i.e. clean equipment)
- managing feral animals

Practical information[54] is available for rural landowners regarding kauri protection, which establishes guidelines and hygiene standards for activities on land where kauri occur. These guidelines focus on reducing the risk of soil transfer and limiting soil and root disturbance around trees (Beauchamp, 2017). 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.

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

[54] Protecting Kauri: A rural landowners guide - https://www.kauridieback.co.nz/media/2050/6617-kauri-dieback-guide-booklet-a5_3_wr_final.pdf)

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 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 Waikato 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 Aotea 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

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 presence of karst in the Waikato 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 highly mobile material (e.g. sand, gravel and mud) and coastal features such as sand spits and bars that are sensitive to natural fluctuations. This dynamic environment also extends into the lower harbours, where there is evidence of shoreline fluctuations (Ryan, 2009).

Ryan (2009) identified in his assessment of the Ōtorohanga District (which likely also applies to the Aotea harbour catchment) that coastal inundation and cliff instability are not significant but that 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 Aotea catchment have less risk of tsunami due to the sheltering effect of New Zealand from the most likely sources of tsunami.

7.3 Identifying Natural Hazards

Natural hazards can cause disruption, damage properties and risk 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 26)[55]. The Portal contains all

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

available (suitably robust) spatial hazard information that is held by Waikato Regional Council, as well as some data from other organisations.

For Aotea Harbour, the portal identifies known and potential hazards relating to:

- Coastal hazards
- Coastal inundation
- 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.

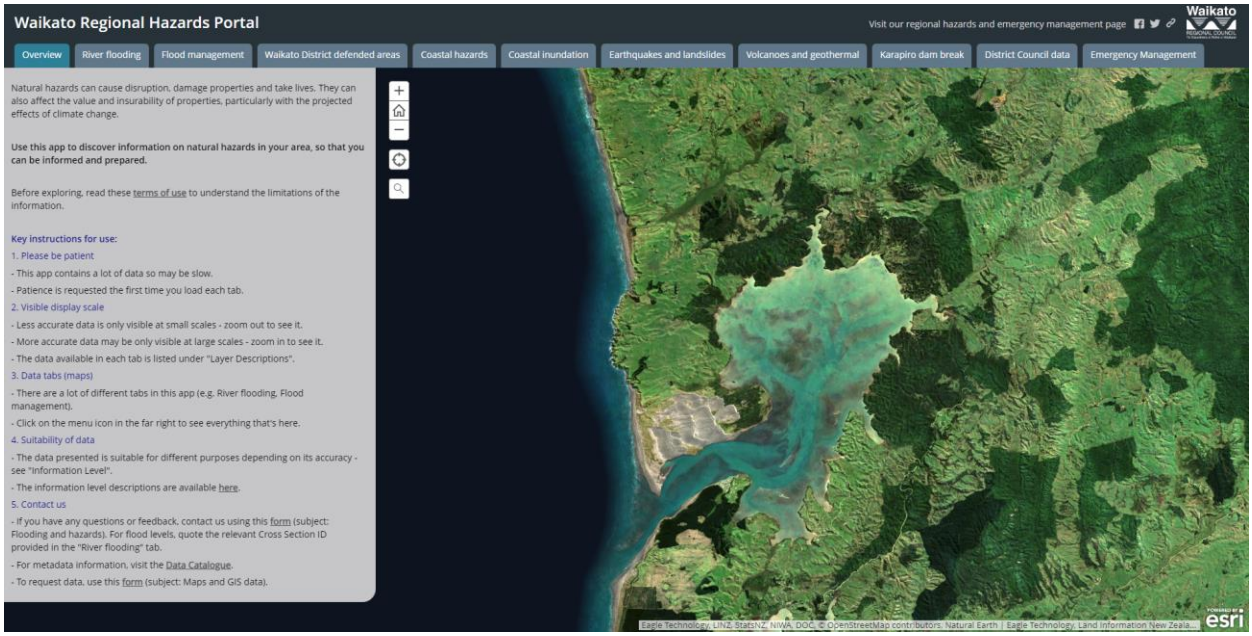

Figure 26. Screenshot of the Waikato Regional Council Hazards Portal. Source: WRC Hazard Portal.

8 Climate Change

8.1 Introduction

Climate change is predicted to affect rivers and streams through changes to base flows, flow patterns[56], 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 and 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.[57]

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 13. In summary, the changes likely to be experienced in the Aotea catchment over the coming 20 to 70 years are:

- Increased temperatures, including:
    - increased daily average temperatures;
    - increased days with high temperatures (over 25 ˚C); and
    - less frosts.
- Increased winter rainfall and reduced spring rainfall but there will be local variation and projections are uncertain.
- Potential increase in westerly wind flow during winter, and north-easterly wind flow during summer.
- 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.

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

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

- 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 13. 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 Aotea catchment

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

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

9 Prioritisation of conservation and restoration activities

Prioritisation of conservation and restoration activities is necessary to ensure resources are utilised in the most effective way. In other parts of the region catchments and sub-catchments have been prioritised in the past to guide catchment management activities.

This section outlines the prioritisation process that have been used in the Aotea catchment.

9.1 Sub-catchment condition rankings

Wildland Consultants Ltd (2014) stated that the aim of their Aotea catchment survey was to spatially define catchment assets and issues, to assist with prioritisation of areas for further investigation, and provide guidance for the implementation of catchment management work programmes. Sub-catchments within the Aotea Harbour catchment condition survey area were ranked from 1 (best condition) to 6 (worst condition) on seven key measures (see Table 14). Six measures were derived from the field survey, while the seventh measure - the level of catchment protection has been derived from analysis of LCDB3. Overall sub-catchment rankings were derived from the means of rankings for each key measure. The authors noted that this method had its limitations. For example, the ranking process could have been extended to include catchment size, steepness, hydrology, and other data sets, such as Land Use Capability and Threatened Environment Categories. Nevertheless it provided a rapid and relatively straightforward indication of current condition.

Table 14. Overall sub-catchment condition rankings for sub-catchments in the Aotea Harbour (Wildland Consultants Ltd., 2014).

Sub-Catchment	Riparian Condition (Native Veg)	Riparian Stock-Proofing	Riparian Erosion	Landscape Erosion	Coastal Condition	Coastal Stock-Proofing	LCDB3 Catchment - protecting Land Cover.	Overall Rank (and Mean Score)
North Harbour	6	1	2	1	3	1	2	1 (2.3)
Okapu	1	6	6	3	1	2	1	2= (2.9)
Pakoka	2	5	1	2	2	5	3	2= (2.9)
South Harbour	3	2	3	5	4	4	5	5 (3.7)
Taparamapua	4	4	5	6	5	3	4	6 (4.4)
Te Maari	5	3	4	4	N/A	N/A	6	4 (3.1)

9.2 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 prioritisation process that involved:

- Dividing the Aotea catchment into six sub-catchments;
- Identifying features, issues and uses of each sub-catchment using a range of information[58];
- Scoring each sub-catchment (and its downstream harbour area) on the basis of a several categories including:
    - Land instability (poor vegetation protection, sediment and erosion risk) – scored as the % sub catchment with moderate or higher risk;
    - Water quality risks (E.coli, N, P, stream bank erosion and stocking risk) – scored as the % sub catchment with moderate or higher risk
    - 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;
    - 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
    - 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 to maximise the biodiversity and community benefits from land and water improvements.

Whilst the prioritisation was intended to be impartial, it was limited by the quality and availability of information and required judgement to determine final priorities. It also relied on Iwi environmental management plans and other documents to determine community aspirations and would have benefited from further Iwi and community input, particularly for the community score. Nevertheless, it provided useful initial guidance on areas of risk and opportunity for the zone plan.

Table 15 shows the final category scores and overall priority rankings for each of the sub-catchments of Aotea Harbour (from Singleton, 2018).

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

Table 15. Outcome of the prioritisation process in Aotea Harbour catchment by Singleton (2018)

Sub-catchment	Land Instability Risk Score	Water Quality Risk Score	Biodiversity Score	Harbour Score	Community Score	TOTAL Score	Rank within Aotea Harbour
North Harbour	24	14	100	8	9	155	6
Pakoka	70	37	26	16	18	167	5
Te Maari	121	54	63	11	10	259	1
Taparamapua	67	53	47	20	15	202	3
Okapu	59	19	102	20	14	214	2
South Harbour	66	0	68	23	38	195	4

The Te Maari subcatchment scored the highest overall (for Aotea and for all West Coast harbour catchments), driven by its high score for land instabiliity risk and water quality risk. North Harbour and Okapu both scored substantially higher than other subcatchments for biodiversity, whereas South Harbour was the highest ranked for community values.

9.3 Waikato Regional Prioritisation Project (WRPP)

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 of the Waipā Catchment Plan (Waikato Regional Council, 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 and potential outcomes. 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, land managers, funding agencies and communities within the wider Waikato region looking to undertake restoration works (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 subcatchments for management of soil conservation and erosion in the Aotea harbour catchment.

The results of the WPF identify the Te Maari and Taparamapua subcatchments as the first and second highest priorities respectively for management of both soil conservation and nutrient risk (nitrogen and phosphorus) (Table 16). This aligns with the catchments identified by Singleton (2018) as high risk for these factors.

It is therefore likely that catchment management works in these locations will lead to more positive sediment reduction and water quality improvements for the harbour catchment than similar work at other locations.

Table 16. Summarised Waikato Prioritisation Framework mitigation estimates for Aotea harbour catchment (Norris et al., 2021).

	Aotea
Total area of combined sub catchments (ha)	16,198 ha
Mean sub catchment area (ha)	2,700 ha
Ranking for soil conservation risk	Te Maari Taparamapua Pakoka Okapu South Aotea Harbour North Aotea Harbour
Ranking for water quality risk	Te Maari Taparamapua South Aotea Harbour Pakoka Okapu North Aotea Harbour
Estimated hill country erosion costs ($)	$5,165,794
Estimated riparian management costs ($)	$3,644,049
Estimated total management costs ($)	**$8,809,843**
Estimated sediment reductions (%)	50%
Estimated nitrogen reductions (%)	16%
Estimated phosphorus reductions (%)	26%
Estimated E. coli reductions (%)	22%

In terms of potential outcomes for the Aotea 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 Aotea catchment is displayed in Table 16. 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 $8.8m. Modelling predicted that this would achieve a 50% reduction in sediment to waterways and a 22% 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 Aotea 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*).

9.4 Catchment works

Waikato Regional Council has an active programme of catchment works within the Aotea catchment, working with landowners, community groups and other stakeholders. Figure 27 shows the properties (shaded in yellow) where WRC and landowners have entered into an agreement for funding, 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).

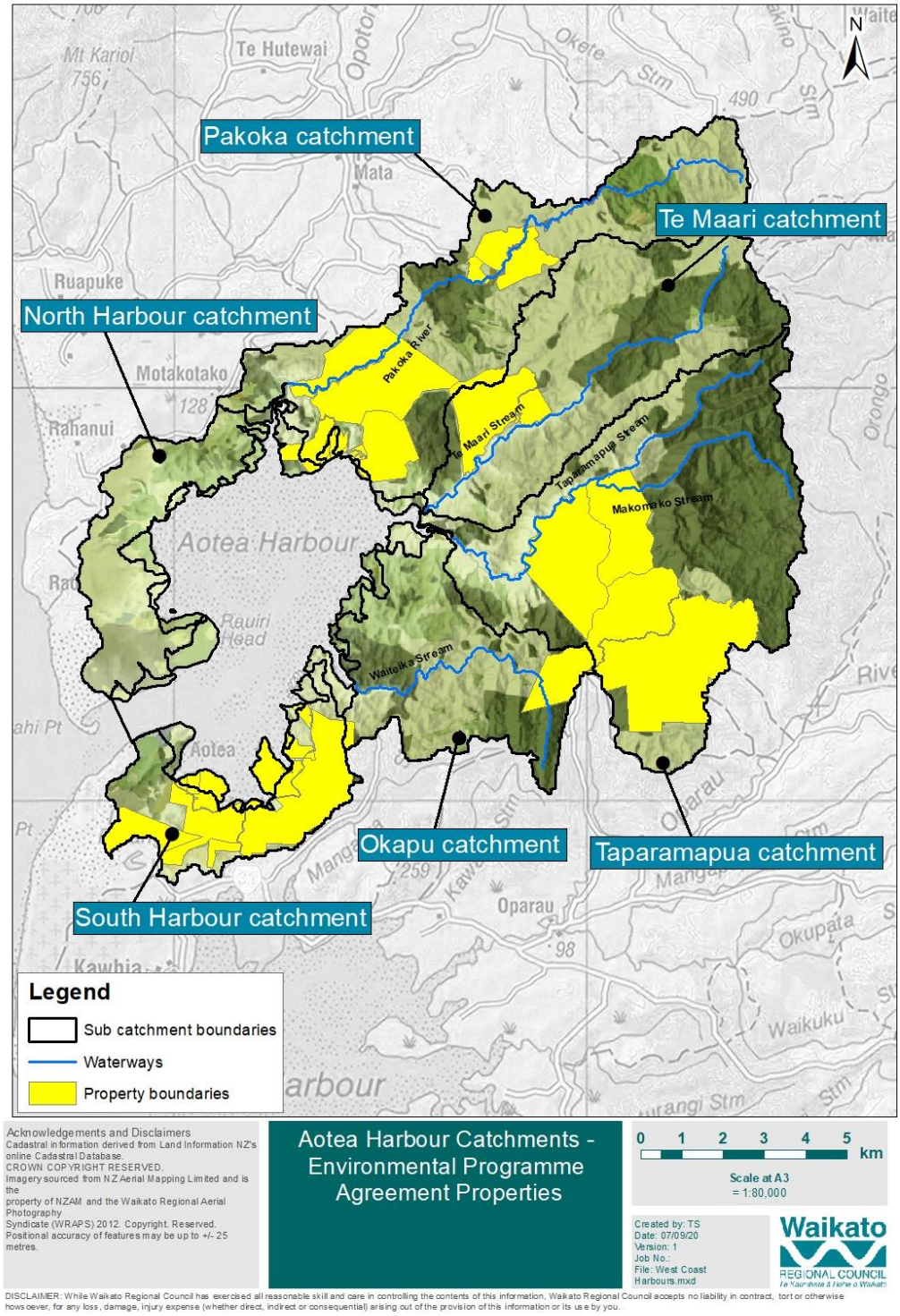

Figure 27. Extent of properties that have Environmental Programme Agreements with the Waikato Regional Council within the Aotea Catchment.

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