Boffa Miskell

Whaka-Ora Animal Biosecurity Prioritisation Strategy

Strategic Pest Control Delivery
Prepared for Whaka-Ora Healthy Harbour

8 August 2023

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Document Quality Assurance

Bibliographic reference for citation: Boffa Miskell Limited 2023. *Whaka-Ora Animal Biosecurity Prioritisation Strategy: Strategic Pest Control Delivery*. Report prepared by Boffa Miskell Limited for Whaka-Ora Healthy Harbour.		
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Status: [FINAL]	Revision / version: [1.0]	Issued: 8 August 2023

Template revision: 20210624 0000

File ref: Strategic_Pest_Control_Priority_WhakaOra_20220802.docx

Cover photograph: Waiake Catchment viewed across Living Springs, Boffa Miskell 2021]

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Abbreviations

CCC	Christchurch City Council
CVNZ	Conservation Volunteers New Zealand
DOC	Department of Conservation
ECan	Environment Canterbury
J4N	Jobs for Nature
LPC	Lyttelton Port Company
PF2050	Predator Free 2050
PFPH	Predator Free Port Hills

1.0 Strategy scope and analytical process

Whaka-Ora is a collaborative partnership that was established through a shared love and concern for the health of Whakaraupō/Lyttelton Harbour and surrounding catchments. Set with a vision of restoring the overall ecological and cultural health, the community, local government agencies, mana whenua and local businesses have been working together to restore a plentiful and thriving environment where natural resources are healthy and abundant. A measure of this success is improved mahinga kai opportunities. The Plan developed to enact this vision is focused on *ki uta ki tai*; from the mountains to the sea, which acknowledges the importance of looking at the entire catchment holistically and investing in the restoration of each ecological component. Firmly embedded in this landscape enhancement is effective and sustained pest animal control, as it is an essential action for restoring the ecological and cultural health of Whakaraupō/Lyttelton Harbour. The collective efforts of the multiple stakeholders that contribute to the Whaka-Ora Healthy Harbour vision will have the greatest impact if they are applied at a landscape-scale. This approach would comprise interconnected trapping networks managed by the numerous groups and agencies operating in the landscape, each serving the single purpose of widescale pest animal suppression. These pest animal control activities will be initiated with the intention to protect native and regenerating forest, support planting sites and improve the ecological integrity in all of the catchments which feed into the harbour.

The intention of this document is to provide strategic direction to the application of pest animal control in the landscape surrounding Whakaraupō/Lyttelton Harbour. This strategy will not form a delivery plan outlining trapping locations, trap density or monitoring methods/targets but rather is designed to be a high-level tool for prioritisation of trapping areas and strategic direction to the ongoing efforts by Whaka-Ora as a collective.

Through targeted predator control, the threatened and vulnerable native fauna and flora can become functional components of the connected landscape. These native species, particularly birds and invertebrates, further aid recovery through their vital role in the pollination of flowering plants and distribution of their seeds. As more remnant habitats flourish, with the pressures of predation and browsing substantially reduced, more mahinga kai species will be present in abundances that support appropriate harvesting and gathering for cultural purposes. Consequently, the measure of success of targeted pest animal control is the recovery and improvement of the habitat. It is therefore essential that the delivery plan develops a biodiversity monitoring protocol with fine enough scale to quantify this change over time.

1.1 Analytical process of this prioritisation

This strategy has required a number of steps to be completed in order to generate prioritisations that are focussed specifically on gaining the greatest benefit from Whaka-Ora pest animal control actions. When the many diverse catchments are initially observed, the problem seems large and complex, however when the catchments are compartmentalised and analysed according to tighter components of the land use and topography then prioritisation can be achieved. This process is described in Section 5.0. Since there are a number of complex attributes across all 16 catchments, a clear hierarchical list of priority locations is not feasible. Priorities will be identified in accordance with important features of each catchment such as native vegetation cover, potential habitat, and waterways.

Decision making does not end with identifying key locations for pest control action. The recent surge in project funding that the region has received has meant that many catchments have the resources and strategic plans necessary to achieve full landscape control of predators and browsers. This negates their need for on-ground support from Whaka-Ora, especially if it is at the detriment of supporting activities in other priority areas. An assessment of current trapping practices and a gap analysis forms an important part of this strategy.

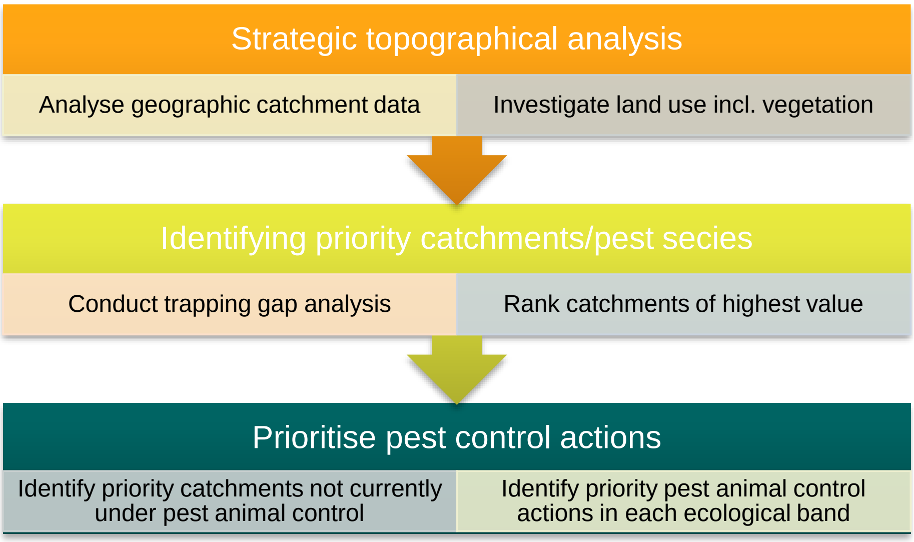

Figure 1 Process for analysis landscapes for pest control prioritisation.

Priority species, generally rare, vulnerable, or identified taonga species, help with prioritisation on a finer scale beyond the opportunities that remnant habitat create. Rather than identify each species and its distribution, the approach has been to identify various habitat types (according to the current Whaka-Ora delivery strategy) and through that attribute pest animal control priorities in each ecological band (Section 7.0). These priority actions being tailored to the pest species which have the highest impact on that habitat type and the flora and fauna which occupy it.

Figure 2 Retired pasture above Purau township.

This analysis can identify key locations where pest control effort is needed to protect current habitat, which in turn supports vulnerable species and healthy functional rivers, improves surface water management and aids the habitat to buffer ill effects of climate change (i.e. stabilise soil and create ecological corridors).

Most of this restoration/conservation work is compromised if stock are allowed to graze on or move across rivers beds and salt marshes. As such it is still imperative that riparian, or river edge, habitat is fenced and planted out with appropriate species. These vital planting sites would require effective ongoing browsing animal control.

The interrelatedness of people and place are essential components of each catchment and long running historic connection to an area cannot be overlooked. However, for the purpose of catchment prioritisation, these contexts must be embedded in the delivery stage and not at this high level initial analysis. Cultural, traditional, historic and community values must play a vital role in delivery decisions and would need to have the conclusions from this strategy fed into any final delivery plan. It is acknowledged that the communities within each catchment, including all landowners, are likely to be an essential component of delivering the on-ground pest control either through granting access to the land or by being participants in the trapping process.

2.0 Achieving the Whaka-Ora vision

The Whaka-Ora plan identifies actions and timeframes in relation to the many habitat types throughout the Whakaraupō/Lyttelton Harbour landscape. The harbour and its catchments were divided into six ecological bands so that the current state of each band could be identified, and the actions needed for a healthy ecosystem could be carried out. The overall vision for each ecological band is shown in Table 1 below. Actions directly linked to pest animal control, or its consequences, have been underlined.

Table 1. Six ecological bands from the Whaka-Ora catchment management plan (Whaka-ora healthy harbour, 2018)

Ecological Band	**Overall vision**
Rocky outcrops and indigenous forests	In the future, we want to see native plants and trees prosper in a sustainably managed environment. We envisage increased vegetation, strong <u>predator control</u> measures, and improved birdlife.
Streams	The long-term plan for these streams is to enhance the riparian margins and water quality to a state where sensitive species are present.
Hills and lowlands	The hills and lowlands of the catchment will have thriving communities of people. There will be an abundance of birdlife, with many kererū in full flight. Locals will be aware of their environmental footprint and look for ways to reduce it through stormwater management, erosion control, and <u>pest animal and weed control</u>.

Wetlands and saltmarsh	In the future, raupō will grow thick within the extensive wetlands and saltmarsh on the flatter areas of the coastline. It will grow alongside harakeke bushes that will be used by local weavers and artists. A labyrinth of watercourses will be established to help wetlands ecosystem where insects, birdlife, and plants will thrive.
Taihua/Foreshore	We want the taihua to be a bountiful food basket in Whakaraupō. Paua, pipi, kūtai will grow, while rock pools will house a range of native species. Greater pest animal control will allow sea birds to breed. Animals and birds can enjoy the natural landscape, while people can make the most of the beaches, walks, mahinga kai activities.
Harbour	We want everyone who uses Whakaraupō to enhance its health. It should remain a recreational treasure for visitors and locals to swim, fish, and use their boats. We envisage a harbour where the waters are free from high levels of pollutants and marine life is thriving. In the future, the Port will grow but will have the ability to cope with increasing demand.

To achieve such a vision, community support and collaboration is essential. Whaka-Ora aims to empower each individual, group, and organisation to feel a responsibility and desire to work together and drive positive changes in the landscape. Over the past few years, this has been exemplified through immense efforts to plant native trees, monitor native flora and fauna, conduct research on ecological populations and sedimentation, controlling invasive pests and weeds, and through converting hundreds of hectares into conservation land.

Wherever possible, Whaka-Ora should seek to support research into improved pest control methodologies and innovative tools for detection or control of pest animals. With the close proximity to Lincoln University, Canterbury University, Manaaki Whenua Landcare Research, Zero Invasive Predator's (ZIP) research centre and Boffa Miskell's biosecurity innovation team, there are many reasons why the Whakaraoupō/Lyttelton Harbour is an ideal location for field trial sites.

2.1 The role of pest control

Pest animal and plant control is essential in the restoration of Whakaraupō/Lyttelton Harbour. This is apparent when considering the visions for each ecological band in Table 1 and how pest animal control or the benefits of its action often features. Even where pest control is not directly mentioned, efforts to revegetate and stabilise riparian margins will require pest animal control to protect the plants from browsing. Browsing mammals have a significant effect on plant survivorship and ecological recovery. The associated reduction in native species composition and plant density minimises habitat and food resources that native fauna relies on. When plants are damaged through browsing, they must then attribute much of their resources into growing vegetative matter rather than pursuing reproduction through flowering, seed production and fruiting. This loss of nectar, fruit, and seed production impacts the survival of reptiles, invertebrates and birds which rely on these food resources (see Table 2). The forest will also struggle to regenerate as fewer seeds are produced, dispersed, and germinated.

Larger browsing animals like deer and goats have the highest impact by removing much of the delicate understory plants in much the same way that livestock does when not properly excluded through fencing. This reduction of understory and habitat integrity around rivers and tributaries (riparian vegetation) reduces water quality and stream bed, or benthic ecology, by increasing sedimentation and changing the nutrients and chemical balance. This has many impacts on downstream ecology and in turn harbour water quality. Increases in benthic sedimentation and high nutrient loads clog the streams with soil, algae and vegetation which reduces insect larvae survival resulting in lower winged insects which many birds like rely on for food. Some exotic deciduous trees are not appropriate along riparian sites as the resulting leaf litter clogs the stream and increases detrimental organic matter smothering the invertebrate habitat.

2.1.1 Importance of biodiversity protection

Birds are the important pollinators and primary seed dispersers in New Zealand native bush and are essential for ecological processes and vitality. Most of the native fruiting plants in New Zealand have evolved to become symbiotically reliant on birds to germinate their seeds by passing them through their gastrointestinal tract. Furthermore, the reduced understory that results from minimal seedling survival leads to a long-term reduction of suitable nesting habitat. This results in fewer resident birds and an overall landscape reduction in successful fledging thus further impacting habitat recovery and restoration attempts. Table 2 indicates the role of each native bird found in, or potentially occupying, the terrestrial habitat around the harbour. Symbols identify the primary food types along with a description of where nesting occurs. The final column indicates the primary predators in accordance with their nesting strategy and foraging behaviour.

Predators like mustelids, possums, feral cats, rodents and hedgehogs, prey on adults, fledglings, and eggs of native birds, as well as invertebrates and reptiles. This in turn further degrades the habitat and diminishes the success of ecological restoration whether it is natural or a result of revegetation. Therefore, the removal of browsing *and* predatory pest animals can have a monumentally positive effect on habitat quality and aid rapid ecological restoration. Further clarification of the direct impacts of each pest animal is outlined in Section 3.0.

2.1.2 Avian fauna as keystone species

Table 2 indicates the nectivorous and frugivorous native birds which are essential components of terrestrial ecosystems as they aid natural restoration and remnant forest expansion. Fortunately, there are a number of introduced birds such as the blackbird which also fills this role. However, our native birds have proven to be highly susceptible to predation when nesting, unlike the European introduced birds which have evolved protective strategies to aid them in avoiding predation. As indicated in the table below, several birds nest on the ground, at least during some of their nesting attempts, which exposes them not only to rodents but larger predators such as feral cats, mustelids, and hedgehogs.

The table also indicates how important invertebrates are in many native birds' diet, being the primary food source for many of the smaller birds. Heathy invertebrate populations are heavily dependent on functional ecosystems and clean productive waterways and as such the protection of habitats from browsing, land clearing and erosion is essential.

Table 2 Terrestrial bird species known/likely to be in the Whakaraupō/Lyttelton Harbour terrestrial landscape

Birds present (*predicted)	**Diet** (key below)	**Nest location**	**Primary nest predators**
Bellbird/Korimako	Nectivorous, Frugivorous	Dense vegetation	Ship rats, possums
Tūī *	Nectivorous	Dense vegetation	Ship rats, mustelids, possums
Silvereye/Tauhou	Nectivorous, Insectivorous, Frugivorous	Tree canopy	Native birds
South Island Tomtit/Miromiro	Insectivorous, Frugivorous	Dense vegetation	Ship rats, possums
Brown creeper/Pīpipi	Insectivorous	Dense vegetation	Ship rats, possums
Grey Warbler/Riroriro	Insectivorous	High in canopy	Ship rats
South Is. Fantail/Pīwakawaka	Insectivorous	Dense vegetation	Ship rats, possums
NZ Pipit/Pīhoihoi	Insectivorous	Ground	Cats, mustelids, rodents, hedgehogs
Shining Cuckoo/Pīpīwharauroa	Insectivorous	Parasitising grey warbler	Ship rats, possums
Long-tailed Cuckoo/Koekoeā	Insectivorous, Carnivorous	Parasitising brown creeper	Ship rats, possums
Kererū/NZ Pigeon	Frugivorous, Herbivorous	High branches	Cats, mustelids, rodents, possums
Kāhu/Swamp Harrier	Carnivorous	Ground in clearing / swamp	Cats, mustelids, rodents
Kārearea/NZ Falcon	Carnivorous	Typically ground	Cats, mustelids, rodents
Ruru/Morepork *	Insectivorous, Carnivorous	Tree / ground cavity	Cats, mustelids, rodents, possums
Pūkeko	Insectivorous, Frugivorous, Herbivorous, Carnivorous	Ground	Cats, mustelids, rodents, hedgehogs
Welcome Swallow/Warou	Insectivorous	Mud nest on a structure	Ship rats
Kingfisher/Kōtare	Insectivorous, Carnivorous	Ground / tree cavity	Rodents, mustelids

Nectivorous Frugivorous Insectivorous Carnivorous Herbivorous

3.0 Pest animal threats in the wider landscape

This section provides a full list of pest animals that are known to be present or have the potential to invade the various catchments of Whakaraupō/Lyttelton Harbour. This list includes browsing animals as well as carnivorous/omnivorous predators. It is important to note that each catchment is not isolated but actually sharing boarders with other catchments such that the risk of pest animal immigration from outside the catchment is always present. Consequently, pest animal control on land that shares a boundary with a focus catchment is essential for the success of any trapping program seeking long term suppression.

3.1.1 Goats (*Capra hircus*)

Goats are notorious for being hard to contain or exclude with the use of fences and are the only ungulate (hooved animal) that can routinely climb trees. Their preferred habitat is forest and open scrubland with exposed sections of grass. They also show a preference for sunny slopes and exposed areas near forest margins.

Goats destroy foliage and strip bark from trees and shrubs, damaging plants and preventing growth or establishment. Goats also trample and eat leaf litter from the forest floor, altering the composition of leaf litter and in turn effecting the abundance and diversity of various litter-dwelling faunal groups (Wardle *et al*, 2001). Leaf litter contributes significantly to soil structure and fertility and may have an important role in carbon sequestration. Goats further impact biodiversity by eat seedlings, preventing germination and reducing forest regeneration. As goats trample the earth, soil material is loosened and mobilised, accelerating erosion (Wardle *et al*, 2001).

Goats are particularly drawn to highly palatable species, like broadleaf and Māhoe, but have a very generalised diet. In the absence of highly palatable species, goats can survive on harsh woody vegetation and other less desirable plants. This capacity enables their persistence in a range of environments.

3.1.2 Deer (*Cervus spp*)

Deer have drastically modified the New Zealand landscape by locally exterminating palatable species and carving trails through undergrowth and sub canopy. They are distributed extensively in New Zealand and occupy both indigenous and exotic forests. Deer prefer to move out of the forest into the open to feed and can form large herds that graze on grasslands day and night.

Deer have selective browsing habits that modify forest understoreys and alter vegetation composition (Dolman & Waber, 2008). The selective nature of deer can have devastating impacts on the function of plants that rely on surrounding vegetation for shelter. Once the understorey is depleted it only takes a few resident deer to prevent palatable plants from recovering. Deer show a strong preference for grazing on Schefflera species, broadleaf, three finger *Pseudopanax* and lancewood. They can cause a severe depletion of indigenous plant cover and diversity.

3.1.3 Pigs (*Sus scrofa*)

Wild pigs are established throughout New Zealand and can occur in both native forest and exotic plantations. Wild pigs eat a wide variety of food including grasses, roots, seeds, invertebrates, and ground nesting birds, all of which are important for ecological interactions. Wild pigs are very destructive to the environment through uprooting trees and saplings and digging topsoil to eat roots, worms, and other important invertebrates. Pig rooting can cause extensive damage to soil microbiology and native plantings in a short amount of time. Furthermore, pigs damage the trunks and shoots of trees and trample fallen logs and subsequently, the biota that finds refuge within these environments.

3.1.4 Rabbits (*Oryctolagus cuniculus*) and hares (*Lepus europaeus*)

Rabbits are included in Canterbury's Regional Pest Management Plan (ECan, 2018) and must be controlled when present in high numbers. Their fast rate of breeding and generalised feeding behaviour ensures that numbers can increase quickly and reach plague proportions when food is abundant. Rabbits and hares pose a risk to young plants with palatable foliage, depleting plant communities and species diversity. Overgrazing by rabbits or hares reduces soil organic matter, which, in turn, deteriorates the physical and nutrient properties of the soil. This impacts the ability of native plants to flourish. Rabbits in particular cause physical disturbance to soil and increase areas of bare ground, promoting the risk of erosion. Hares don't burrow but are more successful colonisers of the steeper terrain found on the Port Hills.

3.1.5 Possums (*Trichosurus vulpecula*)

Whilst possums are opportunistic omnivores, their main diet is leafy vegetation. Possums can spend as much time on the ground grazing as in trees. They eat all parts of a tree including the flowers, fruit, and bark. In turn, the plant's ability to supply seeds, food, or resources to other native flora and fauna is significantly reduced. The effects of possums browsing in the canopy results in significant and often permanent damage to the native vegetation especially when possum abundance is high.

Not only do possums compete with native birds for food resources, but they will also prey on birds and their nests if the opportunity arises. These factors, paired with competition for nest sites, has a devastating impact on native bird populations. Possums have even been confirmed as predators of kea.

Hill side low scrub found throughout the Port Hills landscape and mixed hardwood forest/pasture margins are likely to provide prime habitat to possums. Field sign includes bark chewing, characteristic scats, and the formation of animal trails (pad-trails). These trails aid the movement of other pest animals through the densely vegetated habitat.

3.1.6 Ship (*Rattus rattus)* and Norway Rat (*Rattus norvegicus*)

Ship and Norway rats are amongst the world's most prolific and widespread urban pests. Ship rats are the most numerous rats in New Zealand's landscape and due to their climbing ability have the largest impact on native fauna (Clout & Russell, 2008). Norway rats are most common near human habitation and around waterways. If the environment is stable the rat populations also remain constant. Consequently, an increase in food availability results in higher survivorship and therefore higher resident rat populations. Rats prey largely on birds, eggs, seeds, invertebrates, lizards, larvae and flowers; all of which have ecological functions in a thriving forest. Therefore, the impact of rodents can be observed across the entire ecosystem. Like most animals, the habitat preferences of rats are dictated by the availability of food, water and shelter. If food is scarce or unreliable, they are often present in very low numbers.

3.1.7 Mice (*Mus musculus*)

Mice are prolific breeders and respond quickly to an increase in food abundance, which in-turn drives an increase in rat, and subsequently stoat, populations. This is a well-known predator-prey cycle observed in New Zealand's landscape (Figure 3). In the absence of control only severe winters or predation reducing numbers in areas with unlimited food resources. Selective predation of seeds by mice can alter plant species composition and reduce the forests' ability to naturally regenerate. Mice are also a major threat to reptiles which seek crevices to shelter from predation, since they can access narrow areas that are inaccessible to other predatory mammals. Consequently, mice heavily influence native fauna and flora.

3.1.8 Mustelids - stoats, weasels, and ferrets (*Mustela spp*.)

Mustelids are one of the most devastating pests for native fauna. Their ability to climb trees and swim allows them to reach nests in a range of habitats. The low survivorship of many native chicks, and corresponding decline in native bird populations, can be attributed to the presence of stoats and ferrets. Stoats are highly mobile species which live in any habitat where they can access prey. Their preferred prey are rabbits, but they can switch to eating rodents throughout the year or in their absence the adults, chicks and eggs of native and introduced birds. Ferrets aren't as common in large expanses of forest and tend to populate more fragmented landscapes or vegetation margins. Weasels are smaller than stoats and ferrets, and tend to eat small birds, eggs, lizards and invertebrates. Mustelids are resilient and remain in the landscape in high numbers long after a mouse or rat plague has died off due to food shortage. The reduction in native species across the food web has devastating impacts on ecological functionality and habitat recovery.

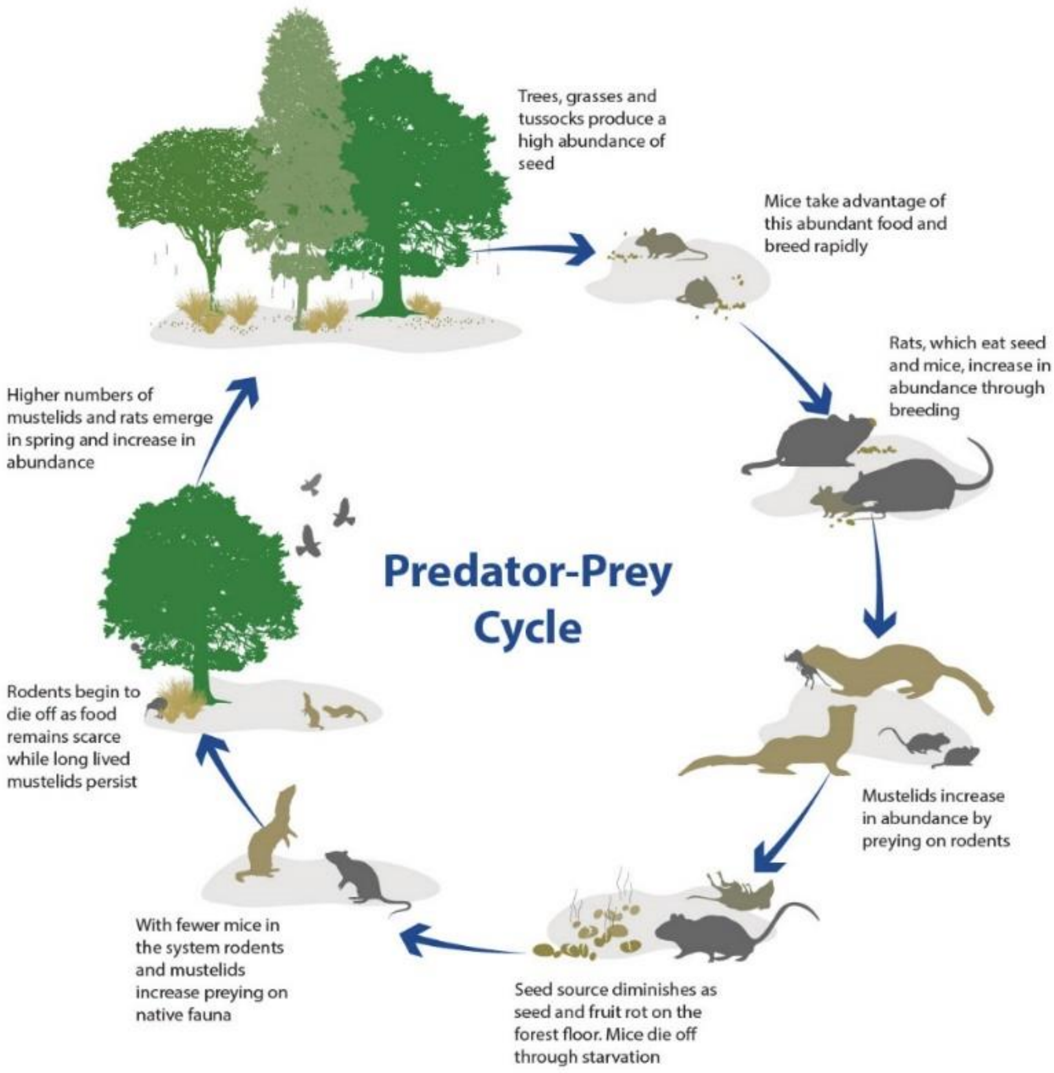

Figure 3 Predator Prey Cycle typical in New Zealand's landscape.

3.1.9 Feral cats (*Felis catus*)

Feral cats are a major threat to native wildlife and biodiversity. A feral cat refers to any cat that is not microchipped or registered on the New Zealand Companion Animal Register, is free-living, unowned and unsocialised, and has limited or no relationship with or dependence on humans (Greater Wellington Regional Council, 2019). Feral cats are specialised hunters that kill most native birds, lizards, fish, frogs, and large invertebrates. Their diet also includes small introduced mammals. Feral cats are particularly detrimental because they specialise to prey on one food group until it is extensively reduced, causing localised reductions in native species.

3.1.10 Hedgehogs (*Erinaceus europaeus*)

Hedgehogs prefer lowland pastoral areas but are known to venture into larger forest tracts if habitat and food are more abundant. Hedgehogs have devastating impacts on a range of native wildlife, particularly birds as they prey on chicks and eggs found in nests. As such they are a priority pest in braided river systems. Hedgehogs also have a voracious appetite for invertebrates, significantly impacting native slug, snail, and insect populations. They have a large distribution within many habitats and are seldom victims of predation by other introduced mammals. Consequently, the only population limiting factors are habitat availability and food resources.

Table 3 Pest animal species distribution and impact specific to the catchments around Whakaraupō/Lyttelton Harbour

Pest Animal Species	Likely impact and distribution around Whakaraupō/Lyttelton Harbour
Goats	With generalist diets, grouping or gregarious behaviour and a natural talent with climbing over fences and up trees, goats are very hard to exclude from large areas of uncleared land. With resident populations in areas such as the Christchurch Adventure Park, goats continue to invade many catchments around Whakaraupō/Lyttelton Harbour. Impacts on the local habitat are severe and continuous until they are removed safely through a cull operation.
Deer	Heavy browsing pressure on native forest and scrub and are detrimental to planting effort. Deer are abundant in some areas of the harbour catchment with higher numbers on the slopes north of Summit Road. Numbers dwindle on the northern section from upper Cass Bay to Godley Head, where they are thought to be completely absent most years. Recent sightings indicate that deer are undergoing a range expansion to areas above Lyttelton towards Godley Head. Carefully coordinated cull operations are needed to control this expansion.
Pigs	Catastrophic impact on soil structure and forest understory through rooting, browsing, and trampling. Mostly present from the head of the harbour around to the southern harbour catchments. Immediate and effective removal is needed and should be guided by a plan or strategy, as small belts of hunting tend to make them shy and elusive. Judas pigs, thermal aerial shooting, or dog teams are all needed for success.
Rabbits/hares	Main impact is on new planting sites and through inhibiting forest/scrub edges expansion (also productivity impact on farming). Present in almost all catchments with hares being more prevalent than rabbits on steep terrain. Shooting, baiting and targeted virus release are valuable tools for rabbit reduction with shooting being the only viable method for hare control.
Possums	Huge impact on almost all forest regeneration, planting, domestic food production and local fauna. Found in very high density in uncontrolled scrub and within highly productive vegetation throughout all catchments. Many tools are available to target possums in the many environments around the catchments with some ensuring minimal risk to non-targets and domestic pets.
Rats	Impact on seed survival, forest regeneration and most native fauna. Social and economic impacts around houses and commercial buildings. In the

	harbour catchment distribution is seasonal and in the dryer months rats are low in valleys and along coastal edges. Expanding their range during spring growth and early autumn fruiting. The tend to pass winter in lower dense vegetated sites or in buildings and structures. Baiting and trapping are viable options depending on the habitat and land use.
Mice	Impacts on seeds and seedlings, invertebrates, and reptiles. Mice also increase the number of other larger predators in the environment as a source of food. When there is an abundance of seeding grasses or a mast year (abundant native plant seeding events) then mouse numbers are very high and can be found from the coastal fringes to the various summits about the harbour. Mice also concentrate around urban dwellings as the cooler weather sets in. Toxic baiting is the only labour effective method of control, however, it has many limitations.
Mustelids	Mustelids are high order carnivores capable to killing native birds much larger than themselves. They heavily impact the survival of penguins and other coastal birds as well as forest dwelling birds, reptiles, and large invertebrates like wētā. All three species are present in fluctuating numbers across all harbour catchments, this being very seasonal and driven by preferred prey items like rabbits and rats (the latter increasing in number as a response to mouse abundance). Ferrets are likely to be present in open pasture edges where it changes to forest or structures, while stoats will move through most habitat even if it is thick and closed in (typically following possum pad trails). Weasels are present in low numbers in most locations. Various styles of baited trap are effective in moderate mustelid control.
Hedgehogs	Hedgehogs have been identified as present in high density throughout a large range of habitats. Their impact on invertebrates, reptiles and ground nesting birds places them as a high priority pest species for control. They are prolific breeders and reach habitat saturation quickly, leading to rapid range expansion and consequently reinvasion of trapped locations. Despite hibernating in winter, hedgehogs have a prolonged breeding period allowing them to have two litters of 4-7 young per year. Hedgehogs are present throughout the Whakaraupō/Lyttelton Harbour catchment and can be targeted with any of the DOC150/200/250 traps (September – June).
Feral cats	Many semi-isolated areas in the hills above the harbour are home to free-ranging feral cats. While many are born in the wild, others may be abandoned or lost post-earthquakes. The environmental impact of wild and domestic cats is substantial. Wild cats need to derive all of their nutrition from the environment so have the largest effect.

4.0 Coastal and river prioritisation

Whakaraupō/Lyttelton Harbour is home to a number of vulnerable or threatened bird species. Many important shore/sea bird species concentrate on the coastline where they are vulnerable to predation, particularly during their breeding season. Consequently, predator control is of particular importance in and around the foreshore/coastline and around wetlands and salt marshes including on Ōtamahua/Quail Island. Figure 4/Appendix 1 indicate a range of marine environments throughout the harbour. In general, the coastline is adjacent to one of three marine habitats (mudflat, estuarine mud or estuarine reef). There are two variations to these: structures such as wharfs, ports and jetties, and the section of estuarine sand northwest of Ōtamahua/Quail Island. The mudflats are particularly important to wading birds which are either migratory species (navigating to the northern hemisphere in winter to nest) or remain in the saltmarsh/wetlands to nest over the New Zealand summer.

Browsing animal control is also important to protect the habitat in this area. Possums are omnivorous and known to predate nests. Hedgehogs are a particular concern as they are present in high numbers, breed rapidly and are a major threat to ground nesting birds. Birds that use burrows like the white-flippered penguin/kororā are at risk from mustelids and rats in particular which can take eggs, chicks, and in the case of mustelids, adult birds off the nest. Wild cats present an elevated risks to a penguin colony because they will specialise in hunting one species until it is locally extinct, often teaching their young the targeted technique.

Due to these risks, and the importance of these shoreline bird species, coastal trapping programmes for all predators should be the first priority in each catchment. An unbroken chain of pest animal trapping around the entire edge of the harbour should be a primary objective for Whaka-Ora. Understandably, some sites will be inaccessible or may require boats for access. These should still be protected where possible and will form a more defendable location for flora and fauna to thrive.

There are three tiers to this high priority objective as outlined in Section 8.0. Initially, trapping networks should be established on the coast within locations where established trapping programs are in place. Locations like Lyttelton Port Company, lower Governors Bay, Ōtamahua/Quail Island, coastal Te Wharau and along the Ngāti Wheke marae shoreline. The locations with higher density housing or urbanisation should be encouraged to trap their coastline in a similar way, particularly in Cass Bay, Corsair Bay, Diamond Harbour, and Allandale where there is intact native bush that can support penguin nesting.

The second tier of activity would be to ensure all of these semi-isolated trapping grids are connected up to each other where practical, i.e. in the absence of high cliffs or bluffs. This would achieve a ring of trapping, and therefore protection, around the entire boundary of the harbour.

The final tier is to increase the density of traps, or over-all trapping area, in locations with intact remnant or regenerating native vegetation which supports nesting of terrestrial and marine bird species.

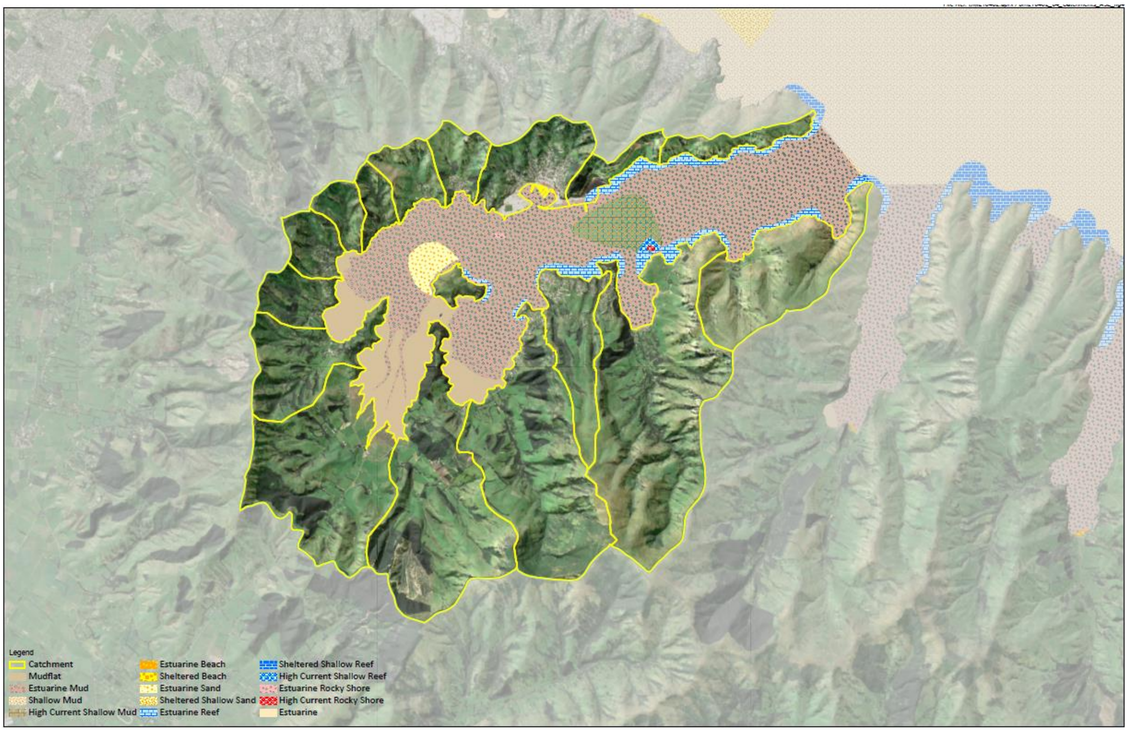

Figure 4 Marine floor and coastal margin terrain in Whakaraoupō/Lyttelton Harbour (see Appendix 1 for full scale map).

4.1 River priority

Awa / rivers are important movement corridors for many pest animal species as are ridgelines, roads, fences, and coastlines. Consequently trapping rivers early on in the catchment trapping network set-up can remove resident and dispersing pest animals simultaneously. Rivers are also a key rat habitat when conditions on higher exposed slopes are either too hot and dry or too cold and wet. Networks of traps along both banks of a river increase the overall protection of the riparian habitat and should be achieved as often as possible. Whether the river is seasonally or permanently flowing, the corridor potential remains high and the habitat it supports on either bank is still vital for the ecology of the region. There are no river systems within any catchments that are not a priority in this strategy, even it if runs through cleared agricultural land or along sections of eroded hillside.

5.0 Topographical analysis

The variable history of each catchment has resulted in a highly diverse land use and remnant vegetation structure. Parameters like land cover and restoration potential must be incorporated into the prioritisation process.

A topographical analysis was conducted across all catchments around Whakaraupō/Lyttelton Harbour using all attributes of land cover. This process of investigation initially required a coarse analysis in order to arrive at finer details of land use, including current trapping practices, that were most important for the prioritisation of Whaka-Ora pest animal control actions.

5.1 Landscape delineation into focus catchments

To aid analysis, the full Whakaraupō/Lyttelton Harbour landscape was divided into 16 catchments (Figure 5/Appendix 2). Some, like Adderley Head, are a combination of smaller catchments with nearly identical topographical or land cover features. This grouping was used to simplify the analysis process by limiting the number of overall catchments for prioritisation. Differences in current land use, soil type, hydrology and aspect resulted in 16 distinct catchments. There are similar trends amongst some of the catchments – most north facing catchments (i.e southern harbour) are large, long valleys ranging from 1,300 to 2,000 ha and close to 6 km long, while the south-facing catchments are much shorter (and therefore steep) ranging from 150 ha - 520 ha in size and less than 2 km long.

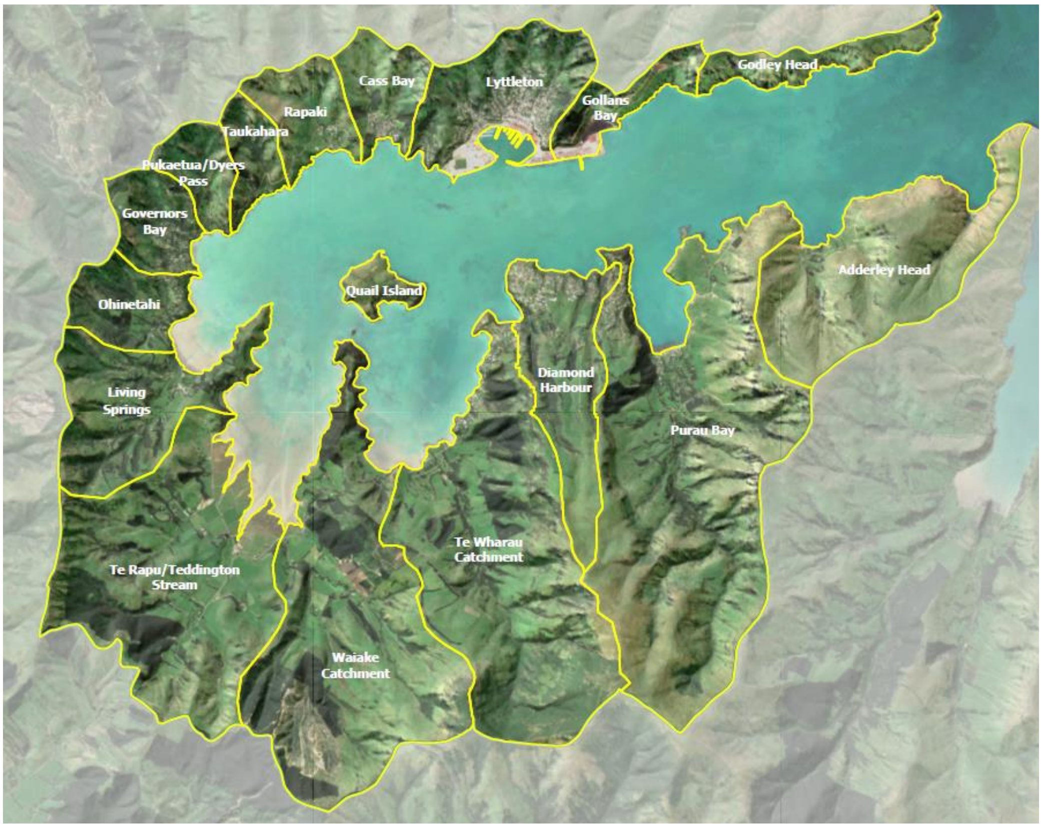

Figure 5 the Whakaraupō/Lyttelton Harbour catchment delineation for analysis purposes (see Appendix 2 for full scale map).

5.2 Analysis of Whakaraupō/Lyttelton Harbour land-use parameters

In order to effectively compare each catchment in terms of land cover, and therefore land use, the entire Whakaroupō/Lyttelton Harbour land was digitised. The resulting landcover area (ha) for 12 land use parameters was calculated within each catchment to allow statistical analysis (Figure 6/Appendix 3). The resulting map below shows patterns of naturalisation, areas where grassland is highly productive, forestry operations, patterns of urbanisation and locations of remnant native vegetation.

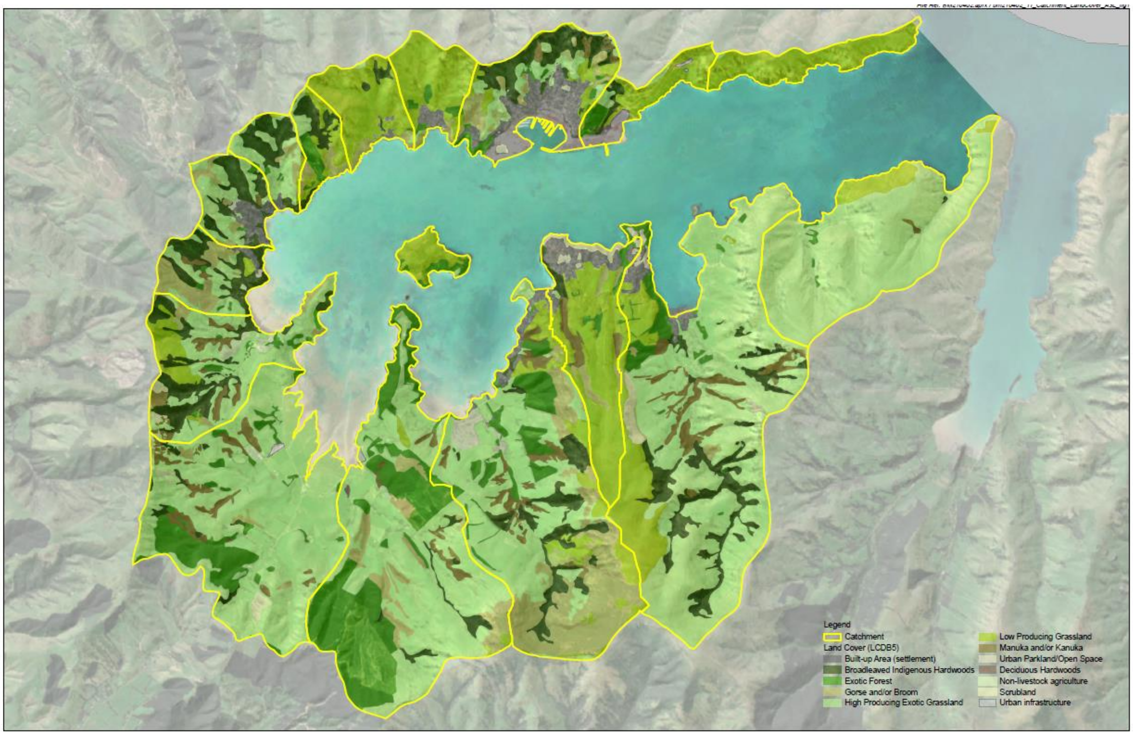

Figure 6 The Whakaraupō/Lyttelton Harbour land area digitised according to 12 land use parameters (see Appendix 3).

5.3 Coarse analysis using overall land cover parameters

The overall catchment area (ha) in Table 4 could be used to order and categorise the catchments, however, this does not represent each catchment fairly. This categorisation does not allow pest animal control prioritisation according to the various attributes within each catchment.

Table 4 Land size in hectares for each catchment

Catchment Name	Size (ha)
Adderley Head	901.7
Cass Bay	230.5
Diamond Harbour	512.2
Godley Head	194.7
Gollans Bay	186.2
Governors Bay	220.7
Living Springs	574.1
Lyttelton	511.1
Ōhinetahi	255.5
Pukaetua/Dyers Pass	166.2
Purau Bay	2066.7
Rāpaki	242.9
Taukahara	151.4

Te Rapu/Teddington Stream	1366.8
Te Wharau Catchment	1548.8
Waiake Catchment	1512.8

The next stage of the analytical process looked at land use primarily in terms of actual native vegetation cover. Figure 7 indicates the total hectarage of native vegetation in each catchment, which included remnant broadleaf hardwood forest, regenerating scrub and kānuka stands. When the total hectare coverage is considered in isolation from the alternative land uses, it clearly indicates three catchments with very large sections of intact native vegetation – these being Purau, Te Wharau and Living Springs in descending order of size. These three sites are greater than 150 ha. This indicates the importance of these three catchments, but still does not provide enough detailed data to assess them against other catchments; because two of these areas are already very large catchments, they would be over-represented in this analysis. It is more significant, therefore, that medium to small sized catchments like Lyttelton, Living Springs and Ōhinetahi feature so significantly in this graph.

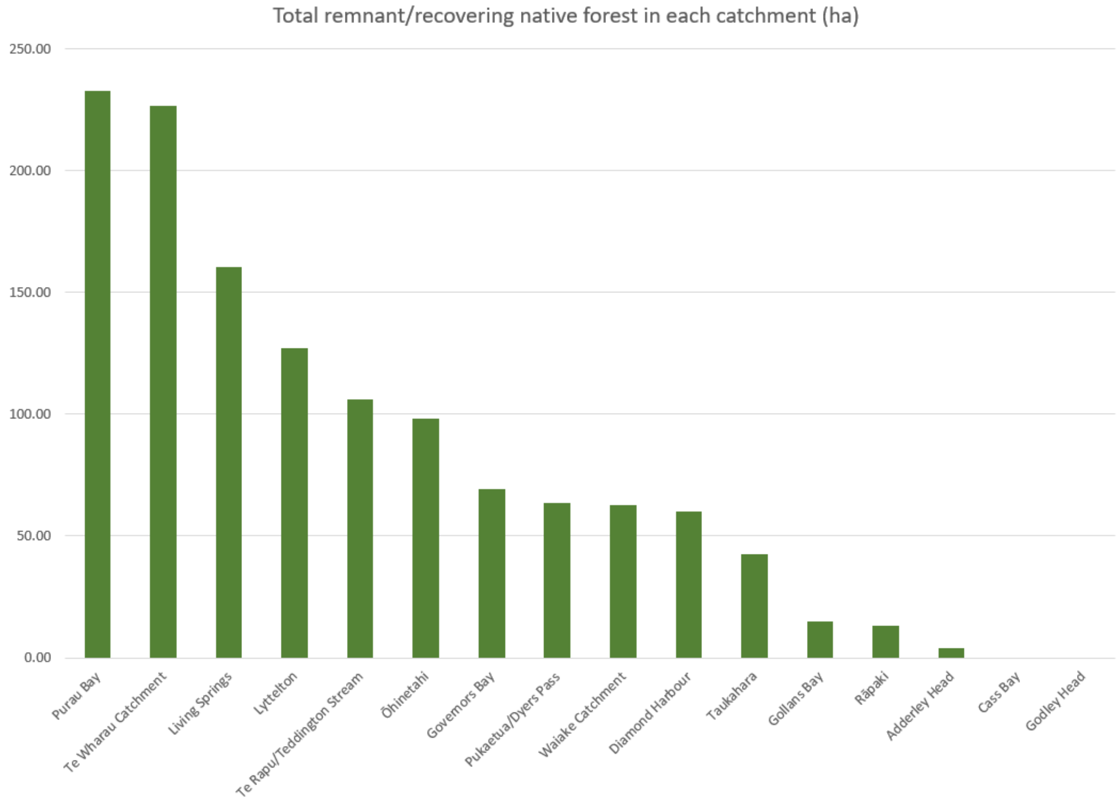

Figure 7 Order of catchments according to total hectares of native vegetation only.

It is evident that assessing catchments by total land cover of native vegetation is not sufficient to guide prioritisation simply because catchment size is so variable. Therefore, within each catchment, the land use data was converted to percentages of total land area (refer Section 5.5). As a result, the catchment was assessed in a way that allows a fair comparison between all catchments.

5.4 Analysis of land use along catchment rivers

Each catchment can be assessed against the other catchments by analysing a number of topographical attributes. One approach is to assess landcover across the length of the river. This was conducted within three catchments to assess its viability for use in prioritisation (Appendix 4-6 and Figure 8). While much can be gained from looking at the land use of various sections of the river, this pertains more to water quality, ecology and sedimentation than informing best pest animal control practices. Riparian planting, stock exclusion and soil stabilisation are practices that are essential for recovering the river systems in the Whakaraupō/Lyttelton Harbour. However, of these and other possible activities, pest control will only influence the productivity and survivorship of native fauna and the success of planting activities in conjunction with protecting already established and recovering vegetation. This has some effect on river quality but an even larger influence on the ecological integrity of the wider landscape. Therefore, focussing only on the river habitat will inhibit big picture or holistic thinking.

In truth, positively impacting water quality and reducing sedimentation can be achieved with any riparian vegetation whether it is native or exotic (within limits previously discussed). However, native vegetation is most preferable over exotic when ecological functionality is paramount. Native vegetation is the most appropriate habitat for healthy invertebrates and avian fauna, providing better foraging and nesting opportunities. This exhibits the interconnectedness of aquatic and terrestrial invertebrates and their impact on avian fauna and flower pollination. Improved avian fauna will also lead to successful seed disbursal and germination further aiding understory recovery and habitat improvement. This does not preclude the importance of reduced benthic (riverbed) sedimentation and improved water chemistry on the aquatic flora and fauna within the system.

Appendix 4-6 shows a profile of three catchments to indicate land use as the awa / river flows down the valley, highlighting the grade of the river as a result of valley length. The length of a river is a very important component of aquatic habitat and water quality. If the river is short and the grade steep, then any rain fall entering the catchment at the top passes through to the harbour rapidly and may wash out high levels of sediment. These tend to be seasonal rivers, unless they are spring fed, and may be dry much of the year resulting in a reduction in aquatic invertebrate populations. Longer catchments with shallow gradients are more likely to be flowing year-round and experience huge variations in flow rates due to the larger land area collecting more rainwater. There is also a higher likelihood of the catchment containing more springs to feed the system. Longer and larger catchments also hold the water on the land for much longer than the short steep catchments and therefore have a more substantial influence on its chemistry and quality. As such, larger catchments that have poor land use practices such as over stocking or heavy use of phosphates and other fertilizers are more likely to leach these into the harbour basin and negatively affect the mahinga kai species which Whaka-Ora seeks to enhance and protect. The wider catchment land use profile is therefore a vital component of analysis not only when considering prioritising pest animal control, but also for understanding impacts on water chemistry and quality.

As a result of the river habitat assessment, the overall land cover data across the entire catchment stands out as an essential parameter for prioritising pest control actions to support habitat regeneration. As surface water management is closely linked to the catchment vegetation cover in terms of density (canopy and root mass) and the overall coverage, effective surface water management is important to stabilise river flow and minimise the erosive forces of high flood events (Alaghmand, 2014).

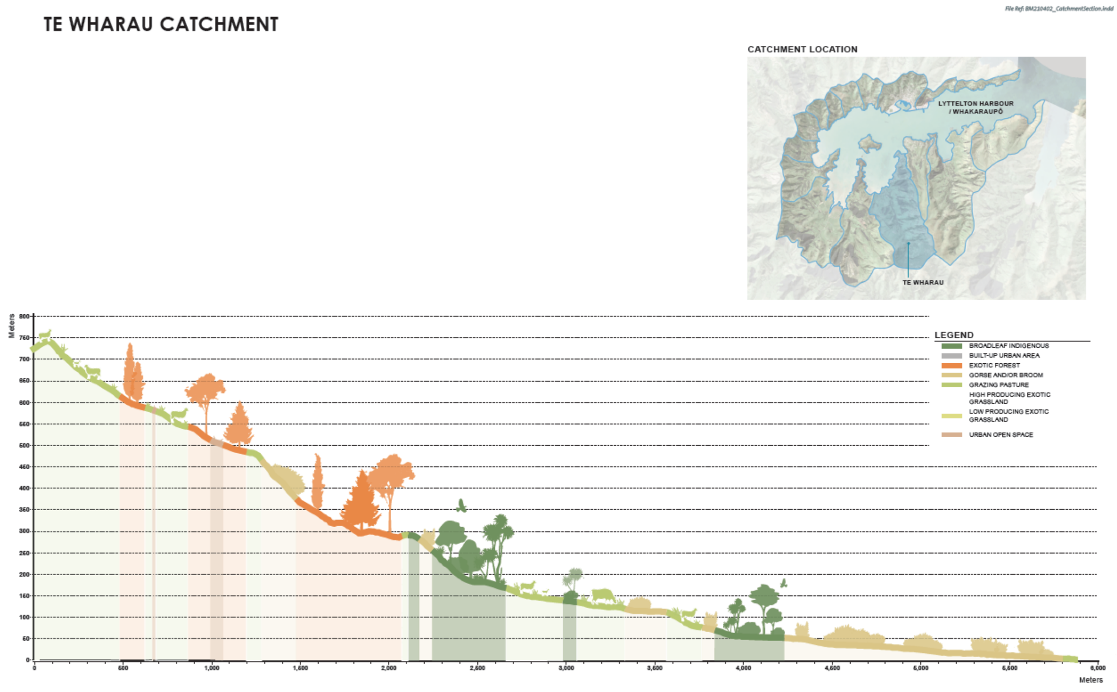

Figure 8 Cross section of river showing land use as it flows down a catchment (also Appendix 4)

5.5 Comparability of catchments with land use as a percentage of land cover

At the conclusion of the initial analysis, it is clear that the most reliable way to compare catchments that are highly variable in land use and catchment size is to convert the land cover/use data into a percentage of the whole catchment (Figure 9). This highlights the significance of features such as remnant native vegetation and exotic forest in terms of total catchment coverage and balances out the influence of pasture and urbanisation. Figure 9 shows each catchment represented as a pie chart for easier identification of catchments with significant areas of remnant/regenerating native vegetation and areas of intensive urbanisation. Living Springs, Ōhinetahi, Governors Bay, Dyers Pass, Taukahara, and Lyttelton all stand out as having greater than 25% land covered in native vegetation. Consequently, if they do not feature high in the final prioritisation then the methodology is not sound. While this visual representation is useful to highlight many features of the landscape, including the prevalence of pasture and the variability of urbanisation, the data needs to be analysed in greater detail and graphed accordingly. This data set was analysed further to develop the priority graphs seen in Figure 10-12 and Tables 5 and 6.

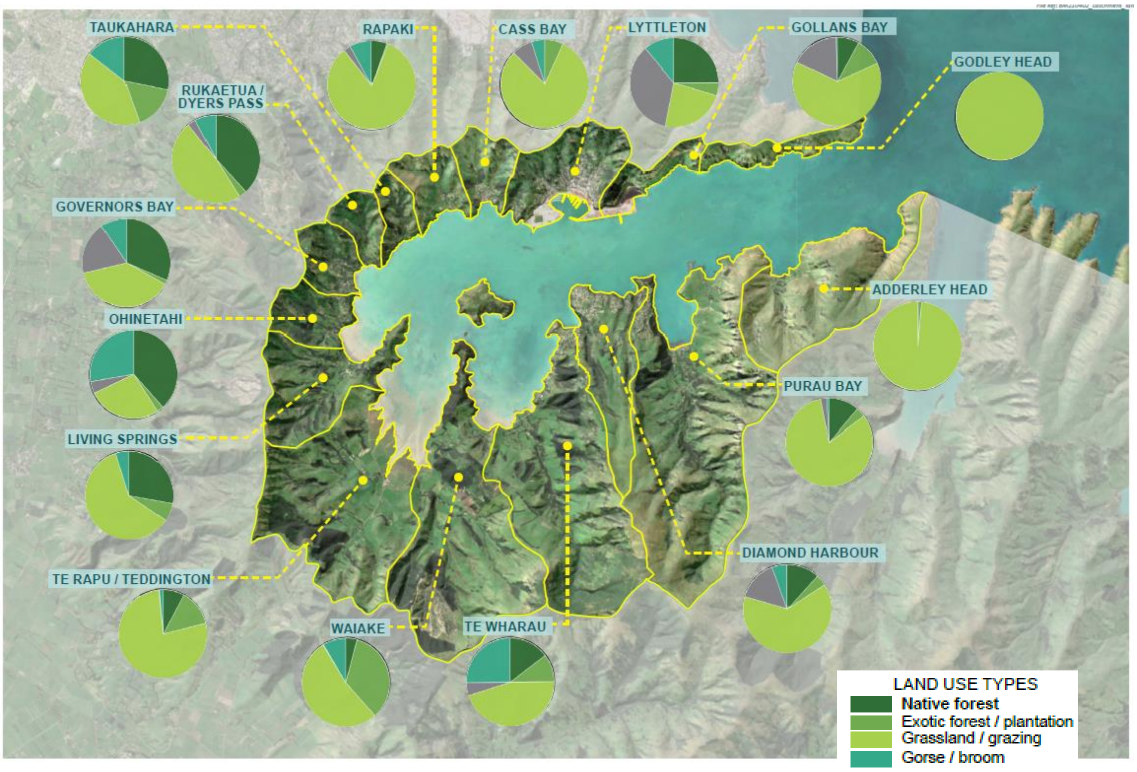

Figure 9 Pie charts showing the distribution of various land use parameters within each catchment allowing easier comparisons for prioritisation (see Appendix 7).

5.6 The outcome of removing urbanisation

Initially, hard surfaces and public spaces were identified and combined into one shape. These included urban and rural land that contained structures, domestic dwellings, roads, schools, and businesses. This classification was extended to include fields, golf courses and sportsgrounds since these contained little in the way of connecting vegetation and were unlikely to be reverted back to native vegetation. This layer was grouped under the term urban.

As outlined in Section 5.5, the analysis of native vegetation as a percentage could generate a more meaningful graph to guide prioritisation if the objective was to prioritise intact ecological habitats worthy of protecting. However, this would only consider the current state and not the restoration potential of each catchment. Figure 10 indicates catchments prioritised according to percent cover of native vegetation on non-urban land. Since hard surfaces and urban land use represent areas that could never be restored and are in fact are likely to be increased in some areas, it was useful to look at land use with the exclusion of urban use. This appeared to allow highly urbanised places like Lyttelton, Diamond Harbour and Governors Bay to be better represented in terms of remnant native vegetation present on non-urban land. Using this as an analysis tool, the catchments could be separated out into three groups: those with greater than 30% of non-urban land covered in native vegetation, those between 10% and 30%, and those with less than 10% (Figure 10). Catchments with low or no native vegetation cover are not necessarily locations of lower priority and may in fact represent mid to high priority due to their connectivity through ecological corridors. They may also represent revegetation priority sites and therefore important locations for browsing animal control. The five highest priority catchments generated from this graph are listed in Tables 5 and 6 to allow comparison with later analytical approaches.

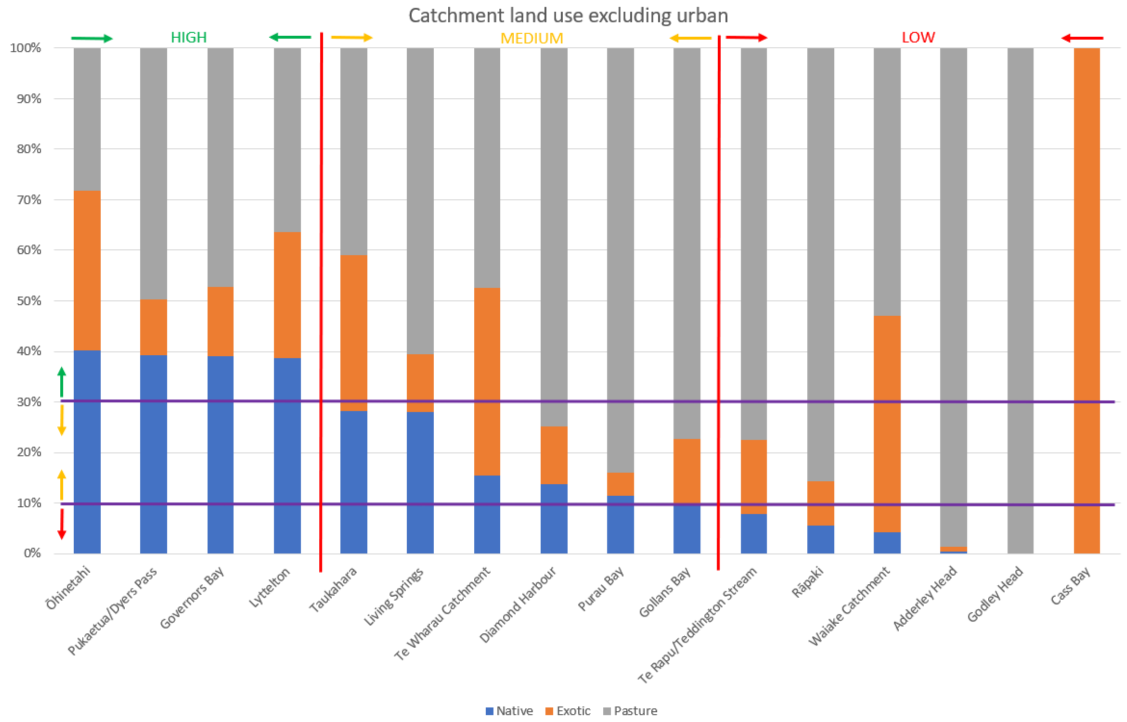

Figure 10 Non-urban land use across the catchments represented as a percentage.

5.7 Assessment according to native and exotic vegetation

The most likely and rapid restoration potential is through conversion of exotic forest to native vegetation. In general, exotic forest aids river protection and bank stabilisation better than pasture or low scrubby vegetation and offers more nesting potential to native birds. However, these forested areas also provide better habitat for browsing and predatory animals and therefore are an important location for pest control actions. Consequently, ordering or prioritising pest control actions in catchments according to forested cover with native and exotic combined is more accurate than just looking at native vegetation by itself.

As this is a full catchment assessment, the urban land use was included and the percent of land cover recalculated for all five land use types – rural, native vegetation, exotic forest, grazing land and gorse/broom. Figure 11 indicates the order of highest to lowest priority of each catchment for habitat protection through pest animal control. Note that the Waiake catchment has critically low native vegetation cover and is misleadingly identified as a high priority through its large plantation forest cover which at this scale is detrimental to local ecological functionality. This analysis better represents each catchment according to its remnant habitat and forest cover compared to earlier analysis represented in Figure 7. This data is represented for comparison in Tables 5 and 6 below.

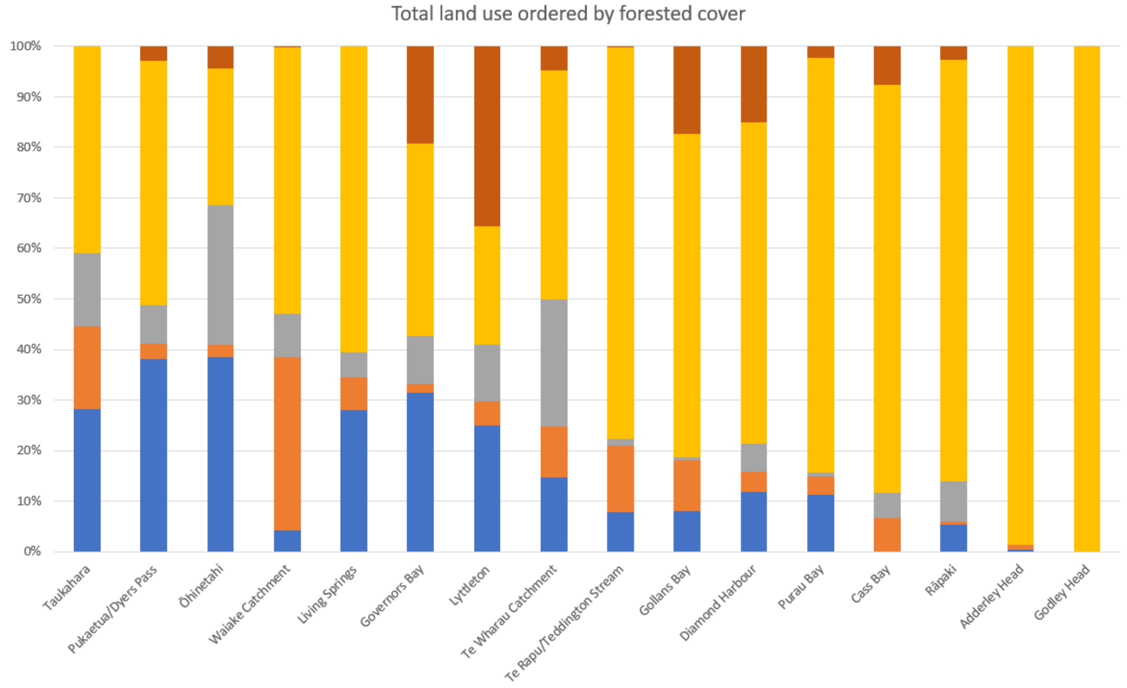

Figure 11 Land use in each catchment ordered according to forest cover (exotic and native combined)

5.7.1 A note on forestry

Production forestry represents a difficult version of exotic vegetation cover because it is cyclically removed which often leads to massive soil erosion events. This is mostly due to the impact of pine plantation on understory growth and soil composition and the actual harvesting process. Rotational logging has a big impact on the surrounding habitat as it leads to rapid displacement of pest animals into the landscape during the tree clearing period. While these areas may eventually be revegetated with native species, this process is slow as the soil needs to be converted back to being productive and nurturing to the new plantings. This is achieved best on a small scale as demonstrated by the recent conversion of a pine block to a tūī corridor at Living Springs. Large scale may be achievable through planting out wetter patches and increasing the spread of this vegetation through natural regeneration, in much the same way that agricultural grazing land is converted. As a result, a catchment such as Waiake, which is largely forestry (34%) and grazing (53%) focussed, will remain a lower priority to other catchments with high revegetation potential until the pine production model shifts and they engage in restoration planting activities. In catchments like Waiake, it is best to focus on the river and coastal margins and corridors on boundaries with catchments that are heavily engaged in trapping. Beyond this remnant vegetation in these pine forest catchments should be protected when resources allow.

5.8 Prioritisation according to total potential habitat

In order to future proof the prioritisation, a final analysis was conducted which ordered catchments according to total potential habitat. Potential habitat, for simplicity, is all vegetated land that is not urban or pasture with the assumption that changes in pasture use will be small scale events giving the huge area already cleared and grazed. The resulting graph therefore references native vegetation, native bush/scrub, exotic forest, plantation, and gorse/broom.

There are many reasons for using this model for pest animal control prioritisation. Firstly, this combined habitat is able to support all pest animals, long term through their various life stages. Secondly, regeneration occurs in all areas where wind or bird seed disbursal is possible as is evident in many historically gorse covered hillside around banks peninsula (acknowledging that forestry logging tends to interrupt this process). The final reason is that restoration planting through conversion of land currently covered in vegetation is more functionally possible than conversion of pastural land. Therefore, catchments assessed according to overall vegetation cover as a percentage is the best impartial method of prioritisation. Figure 12 indicates the distribution of catchments from highest to lowest priority according to this analysis, with Ōhinetahi being of higher priority than Godley Head. This provides a more realistic distribution of catchments than any of the other previous investigations. However, for transparency, the results of all four forms of analysis have been tabulated for the top five priority catchments and presented in Table 5. This allows testing of the data and reveal catchments that consistently appear as top priorities throughout this analysis process.

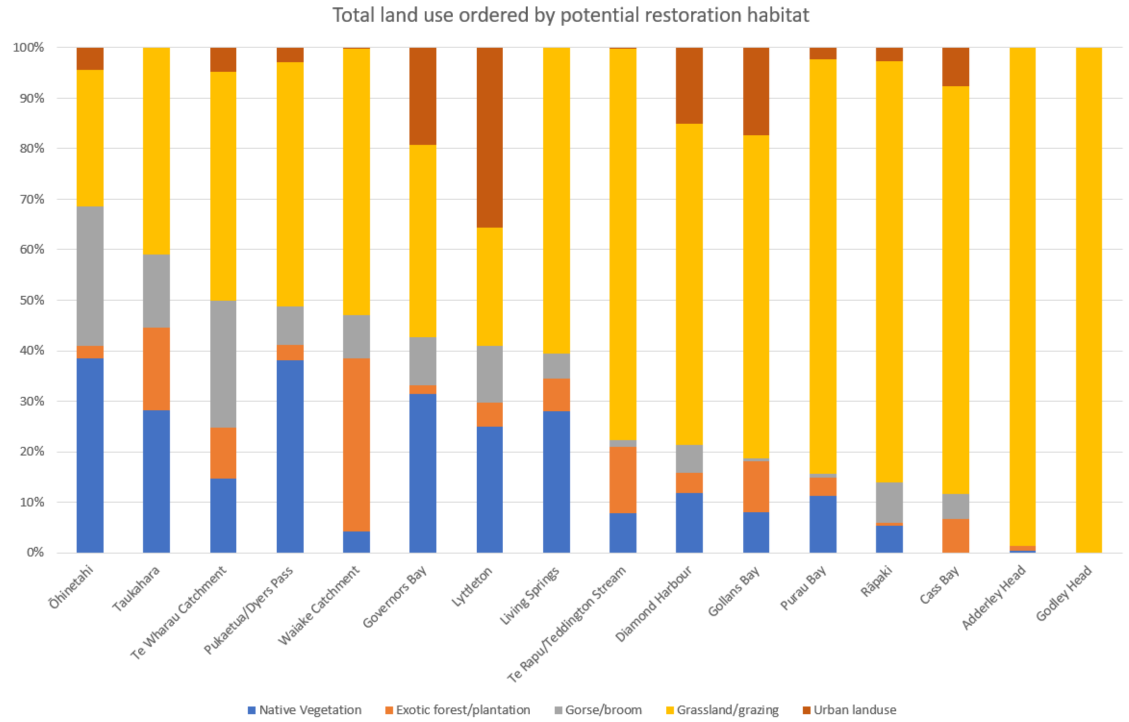

Figure 12 Catchment prioritisation according to potential habitat (exotic, native and gorse combined)

Table 5 Top five priorities according to four forms of analysis with all catchments represented.

Form of Analysis	1st priority	2nd priority	3rd priority	4th priority	5th priority
Total native vegetation cover #	Purau	Te Wharau	Living Springs	Lyttelton	Teddington
Percent native cover of non-urban land	Ōhinetahi	Dyers Pass	Governors Bay	Lyttelton	Taukahara
Total forest cover (native or exotic) *	Taukahara	Dyers Pass	Ōhinetahi	Waiake	Living Springs
Total potential habitat in each catchment *	Ohinitahi	Taukahara	Te Wharau	Dyers Pass	Waiake

*# actual cover calculated in hectares * presented as a percentage of total land cover*

Although appearing to be a priority when looking at total potential habitat, Waiake is predominantly covered in forestry and pasture which might never be converted to regenerating native vegetation. As such, it needs to be removed from the high priority list (see Section 5.7.1). Furthermore, there are four catchments that have the adequate funding, expertise and labour to complete their own trapping networks. By removing these well-resourced catchments, we can better observe catchments that are the highest priority for Whaka-Ora. These Jobs for Nature - Mahi mō te Taiao (J4N) funded catchments are Rāpaki, Taukahara, Living Springs, and Te Wharau. A large section of Purau has some funding for predator control but as this is not sufficient for that site to achieve a suitable tapping network, it remains in the priority list for analysis and can still be seen in relation to the top five priorities below by referring to Figure 12.

Table 6 Five highest priority catchments when current J4N project catchments have been removed.

Form of Analysis	1st priority	2nd priority	3rd priority	4th priority	5th priority
Total native vegetation cover #	Purau	Lyttelton	Teddington	Ōhinetahi	Governors Bay
Percent native cover of non-urban land	Ōhinetahi	Dyers Pass	Governors Bay	Lyttelton	Diamond Harbour
Total forest cover (native or exotic) *	Dyers Pass	Ōhinetahi	Governors Bay	Lyttelton	Teddington
Total potential habitat in each catchment *	Ōhinetahi	Dyers Pass	Governors Bay	Lyttelton	Teddington

*# actual cover calculated in hectares * presented as a percentage of total land cover*

6.0 Gap analysis of current trapping regimes

National conservation movements such as Predator Free 2050 (PF2050) have elevated the status of pest animal control and rallied New Zealanders to a shared goal. As pest control gains significance, more industries, communities, and individuals are playing their part. What was once an action tasked to agencies such as Department of Conservation (DOC) or Christchurch City Council (CCC) is now common practice by many stakeholders such as the local rūnanga (Ngāti Wheke), Living Springs, Summit Road Society, Predator Free Port Hills (PFPH), Lyttelton Port Company, Purau and Orton Bradley.

This increased effort for the delivery of pest control strategies comes at a cost. Funding has been more prevalent in this area of conservation action thanks to contributions from PF2050 and the Jobs for Nature - Mahi mō te Taiao programme. These agencies are delivering government funding to achieve landscape scale pest control and restoration planting while also generating job opportunities in the local area. CCC has also gained grants to increase their work teams and deliver more pest control in the wider land scape. Conservation Volunteers NZ are also now able to deliver more work over a larger area thanks to the increase in funding available. It now appears that the real limitation to restoration planting and pest animal control is no longer labour, but the availability of essentials such as dry wood for trap boxes, trap hardware and plants of sufficient size for each planting season.

In order to conduct a complete gap analysis of the trapping practices in the Whakaraupō/Lyttelton Harbour, complete data sets were retrieved from all groups actively trapping in the area including those listed above and any smaller scale community trapping programs. The results of this are mapped in Figure 13. Each trap has been given a buffer or 'zone of influence' of 200 m as this is the reasonable influence a trap would have on the surrounding landscape when balancing out the relatively small homes ranges of rodents with large home ranges of possums, wild cats, and mustelids.

As the local J4N projects are only one year into their three-year operational programme, the map was annotated to include the currently funded planned pest control activities within each of their catchments. This is indicated in yellow in Figure 14. This indicates the substantial dedication and effort that these teams are putting into habitat conservation in the Whakaraupō/Lyttelton Harbour area.

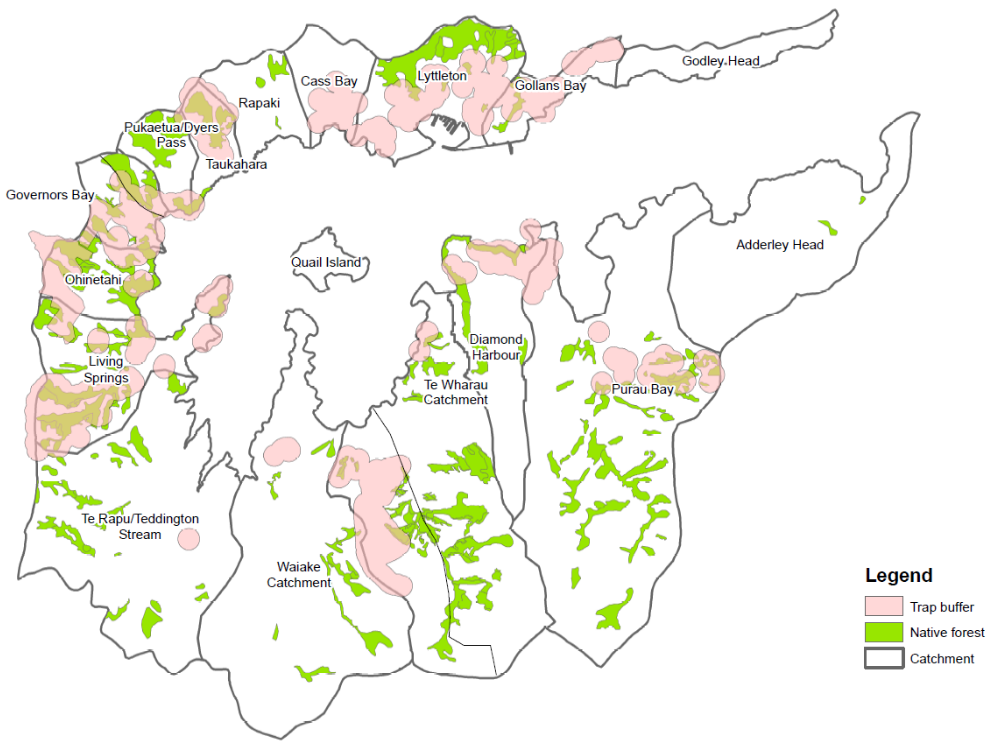

Figure 13 Area covered by current trapping practices, targeting various species. Trap influence radius is set to 200m.

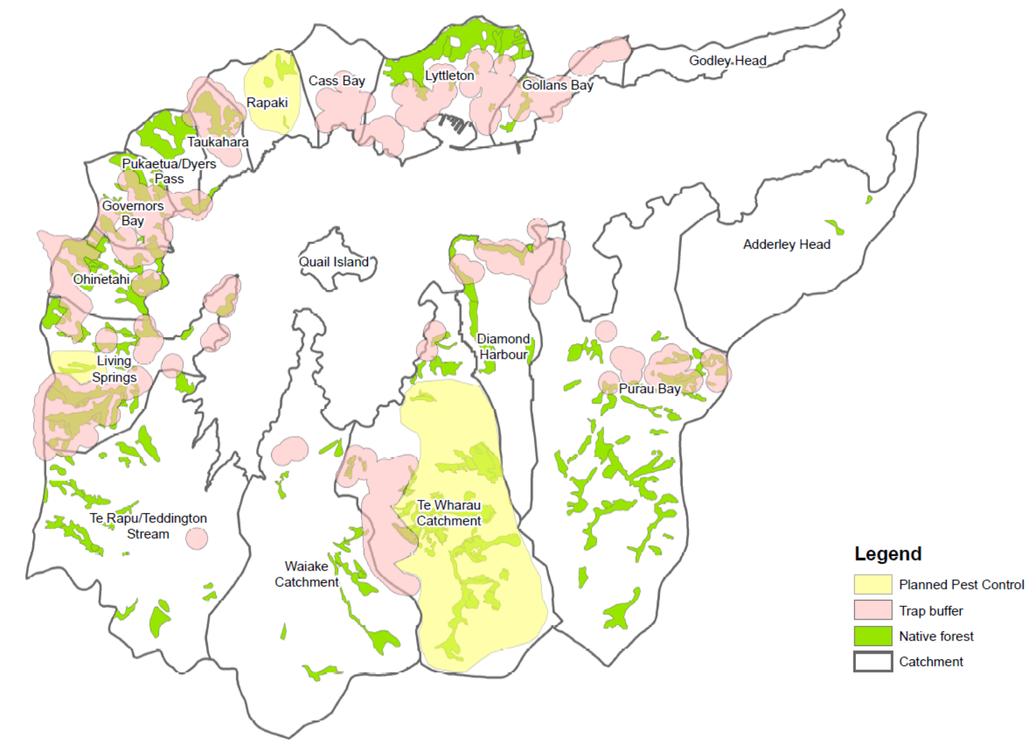

Figure 14 Current trapping locations and planned trapping networks that are currently funded by J4N.

Whaka-Ora has a vital role in helping to fill the gaps in that landscape where many of these stakeholders and community groups are not able to operate. This gap analysis helped to understand the current state of trapping practices, with particular focus on native vegetation, and through this process it can identify specific habitat that is a high priority to achieve a landscape scale approach. This alone would aid Whaka-Ora to focus their trapping effort to ensure that they can achieve their objectives, however, the data analysis was essential to identify which of these areas should be approached as a first priority. As there are currently pest control strategies in place for a number of catchments, this analysis takes into account the future trap networks which will be achieved over the next few years. Consequently, this allows this gap analysis to be more meaningful across a longer timeframe. As with many operational plans this gap analysis will need to be updated every six months for it to be an accurate resource.

Figure 15 indicates the final results of combining catchment pest animal trapping priority generated from the analysis of land cover use in Section 5.7.1 with the adjustment that results from including J4N funded activities within the gap analysis. This map indicates where Whaka-Ora is best to engage in pest animal control to support local ecology and facilitate the efforts of others in the wider landscape. These are presented as those sites of highest priority and those that would be approached later with adequate funding. The final delivery decision should include historic and cultural values before proceeding with any trap network setup.

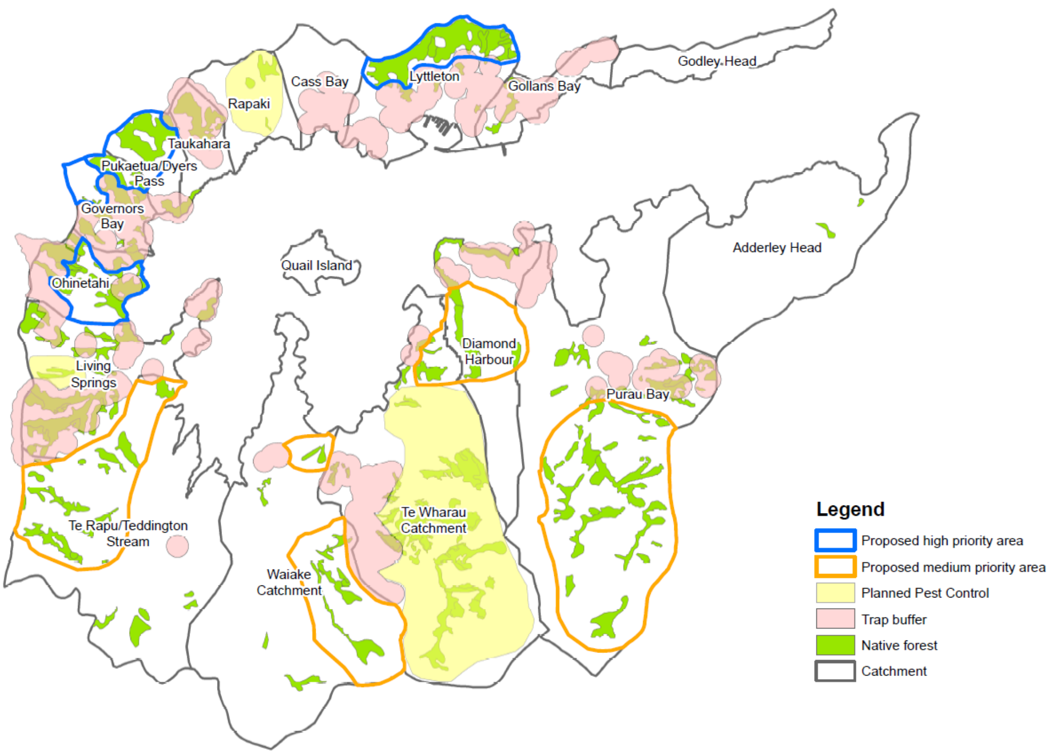

Figure 15 High and medium priority sites for Whaka-Ora focus amongst known and planned trapping networks.

When considering the catchments listed as medium priority, the areas indicated in Figure 15 are purposely centred around the remnant native vegetation. However, other areas may become more of a priority if they support current trapping practices in the neighbouring land or if land access and stakeholder motivation enables easier establishment of a new trapping network.

7.0 Pest animal species control prioritisation

To understand the role of pest control in Whakaraupō/Lyttelton Harbour, we need to determine what we are seeking to protect in the landscape and then identify what pest animal species are present and the impact they are having on priority native flora and fauna. This strategy has now identified catchments with significant natural value which need to be protected. It has also indicated catchments, or specific locations within catchments, that will compliment current trapping programs and complete the landscape-scale pest animal control objective. This section can be used to tailor the trapping program according to the ecological bands identified by the Whaka-Ora Healthy Harbour Plan. When establishing new trapping programs in the priority sites the best procedure is to identify the various ecological bands and engage in trapping to target the priority pest species outlined below (Table 7).

Table 7 Keystone species and priority pest animals and control within the five terrestrial ecological bands within Whakaraupō/Lyttelton Harbour (Whaka-ora healthy harbour, 2018)

Ecological Band	**Keystone species within the ecosystem**	**Priority pest animal species and tools**
Rocky outcrops and indigenous forests	Native fauna and flora - especially these taonga species: • *invertebrates* – copper butterfly, Canterbury tree wētā. • *reptiles* – waitaha gecko and Canterbury skink. • *avian fauna* – pipit, kārearea/falcon, kāhu/harrier. • *native flora* – pōhuehue/muhlenbeckia, prostrate kowhai, thin-barked totara, tussock.	Small mammals (rodents, mustelids and hedgehogs) using DOC200/250 style traps and large snap traps. Possum control using suitable methods - tree mounted traps, contract shooting, bait stations. Ungulate control through carefully planned contract hunting. Stock exclusion is essential for understory recovery. Bait stations for mouse control around reptile habitat. Possum and feral cat control with cage and leghold traps.

Hills and lowlands	• *invertebrates* – red admiral butterfly • *reptiles* – jewelled gecko • *avian fauna* – rūrū/morpork and kererū • *native flora* – kanuka, totara and whauwhaupaki/five-finger	Small mammals (rodents, mustelids and hedgehogs) using DOC200/250 style traps and large snap traps. Possum control using a number of suitable methods - tree mounted traps, contract shooting, bait stations. Possum and feral cat control with cage and leghold traps. Ungulate control through carefully planned contract hunting.
Streams	• *freshwater invertebrates* – kōura/crayfish and kākahi/mussel, caddisfly, stonefly and mayfly • *aquatic vertebrates* – Tūna/eel, kanakana/lamprey and kokopu • *avian fauna* – pūkeko and kōtari/kingfisher • *native flora* – pūhā/wattercress	Small mammals (rodents, mustelids and hedgehogs) through the use of DOC200/250 style traps and large snap traps. Possum control using methods - Tree mounted traps, contract shooting, cage and leghold traps. Ungulate control through carefully planned contract hunting. Stock exclusion is essential for habitat recovery.
Wetlands and saltmarsh	• *invertebrates* – mud crab • *aquatic vertebrates* – inanga/whitebait • *avian fauna* – pūkeko and tōrea/oystercatcher • *native flora* – harakeke/flax, kahikatea and seagrass	Small mammals (rodents, mustelids and hedgehogs) using DOC200/250 style traps and large snap traps. Stock exclusion is needed for ecosystem functionality. Possum and feral cat control with cage and leghold traps.
Taihua/Foreshore	• *invertebrates* – pāua, pipi and kūtai/mussel	Small mammals (rodents, mustelids and hedgehogs) using DOC200/250 style traps and large snap traps

	• *avian fauna* – karoro/seagull, kūaka/godwit and kororā/white-flippered penguin	Possum control in vegetated coastlines - tree mounted traps cage traps

Figure 16 DOC200 trap box fixed partial lid design.

8.0 Strategy conclusion

The following priorities have been derived from the analysis discussed throughout this document (Figure 17). The pace at which each tier of priority is achieved will rely heavily on available funding, resources, and labour. However, a 12-month period would be the ideal timeframe for each tier to be achieved.

It is imperative not to stretch resources and effort too thinly, i.e., have so many traps to check and maintain across a great distance that it is no longer sustainable. As each catchment network is rolled out it, must have local community support and that of CCC/CVNZ style roving teams. Whaka-Ora pest control teams should be focusing more on establishing the next network rather than spending increasingly more of their available time going back to check and maintain established networks. Empowering local community groups to be involved and gaining community buy-in is essential to the success of these networks.

Of the catchments that are not receiving Jobs for Nature funding, the four highest priorities are Dyers Pass, Ōhinetahi, Lyttelton and Governors Bay (Table 6). Therefore, these are the catchments in which Whaka-Ora should focus their pest control actions. Some of the larger remnant native vegetation in these catchments are under DOC or CCC management and as such, Whaka-Ora should petition DOC and CCC to initiate pest control activities to complement Whaka-Ora and other stakeholders pest animal control actions. Furthermore, support should be offered to the efforts currently underway in Purau where significant remnant vegetation exists in the Hidden Valleys.

While the Whaka-Ora team are getting set up with access and sufficient hardware, labour and logistics for the main focus/priority projects, short term effort should be focused be placed on trapping pest animal corridors adjacent to the J4N trap networks (Tier 1, Figure 17). Once the four top priority catchments have been trapped effectively, the next priority is to support the habitat still present in the next priority catchments of Teddington, Diamond Harbour, Purau (upper valley) and Waiake (eastern). When addressing any of these catchments, initial focus should be placed on the river vegetation to support the local ecology and increase the likelihood of trapping success in the early stage. Exact locations of trapping effort and the types of pest animals targeted should be directed by the details in Table 7 which outlines the priority pests and methods of their control according to the various ecological bands identified in Whaka-Ora Healthy Harbours Plan. As previously discussed, initial stages of trapping should be concentrated around rivers where possible.

The creation of a continuous ring of traps around the entire coastline of Whakaraupō/Lyttelton Harbour should be actioned simultaneously as the team establishes catchment trapping networks. This is likely to be achieved in a three-tier approach demonstrated in Figure 17 but further clarified in Section 4.0. These approaches are recommended because rivers and coastlines are well known corridors for dispersing pest animals, sometimes funnelling them in the landscape, and are locations of high biodiversity value (while still providing rich habitat for resident pest animals). This combination is detrimental to ecological stability unless pest animals are removed from the habitat and permanently excluded. If removal and exclusion is not possible then broad scale suppression must be the trapping objective.

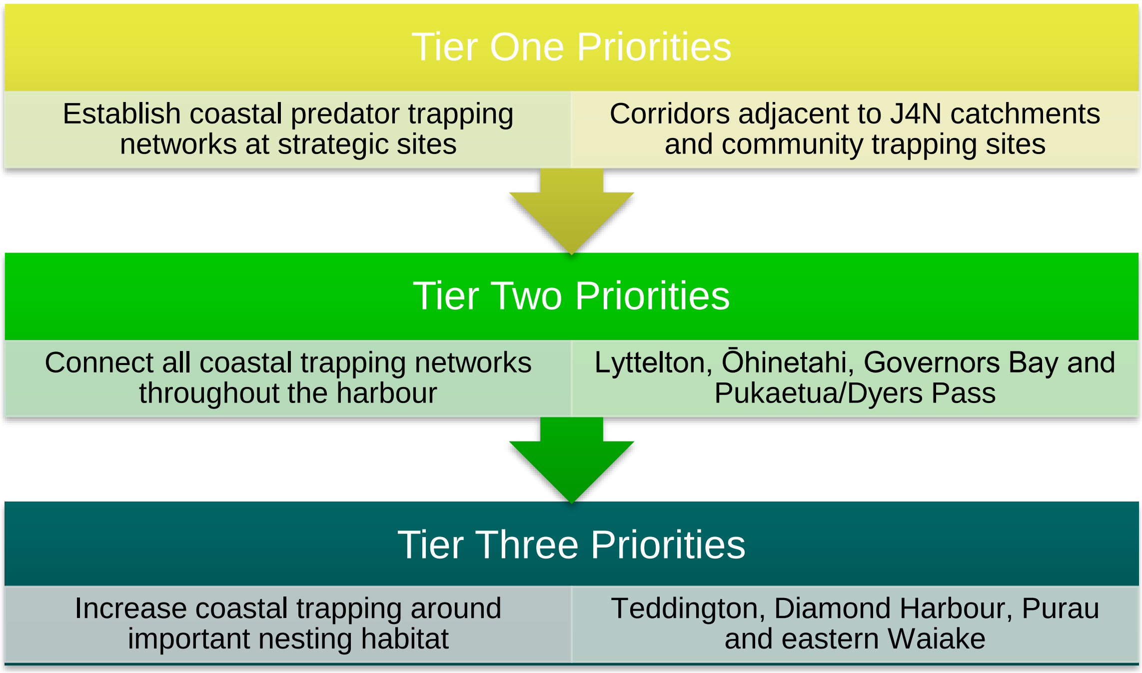

Figure 17 Three tier prioritisation plan for costal and terrestrial environments.

With any strategy, the ultimate value of this document is to guide the development of a delivery plan and to assist in attributing, or applying for, funding effectively. A delivery plan should incorporate the recommendations of the strategy while maintaining flexibility to respond appropriately to the realities of setting up a functional trapping network on the ground. The strategy should guide decision making, but as previously stated, the social context of all sites must also play a vital role in delivery. Therefore, both the strategy and delivery plan must be fluid living documents and updated often to incorporate changes in landscape trapping activity, both increases and decreases, and land use or access changes. It is recommended that a document be obtained, or developed, outlining the most appropriate pest control tools for use in rural or urban landscapes with reference to each target species. This should outline the benefit or risk of each tool, risk mitigation options and what tools are not appropriate in certain situations.

To assess the success of any Whaka-Ora trapping programme, appropriate biodiversity outcome monitoring needs to be established. The scale and location of a monitoring programme will depend on the trapping networks eventually established. Results monitoring, or collation of the trapping data, is also imperative and should be carefully considered. The most appropriate tool is Trap.NZ.

Sustained and effective pest control is one of the vital actions needed to help Whaka-Ora achieve their vision of a cleaner harbour with healthy catchments leading to increased mahinga kai opportunities. This strategy has been developed to embed Whaka-Ora pest animal control activities seamlessly into the current landscape actions resulting from the dedication of many stakeholders and communities. The resulting delivery plan should merge this strategic assessment into the on ground social, cultural, and political context of each catchment to achieve the greatest outcomes in the shortest period of time. Only when these actions are sustainable and have longevity will a legacy of pest suppression be achieved.

9.0 References

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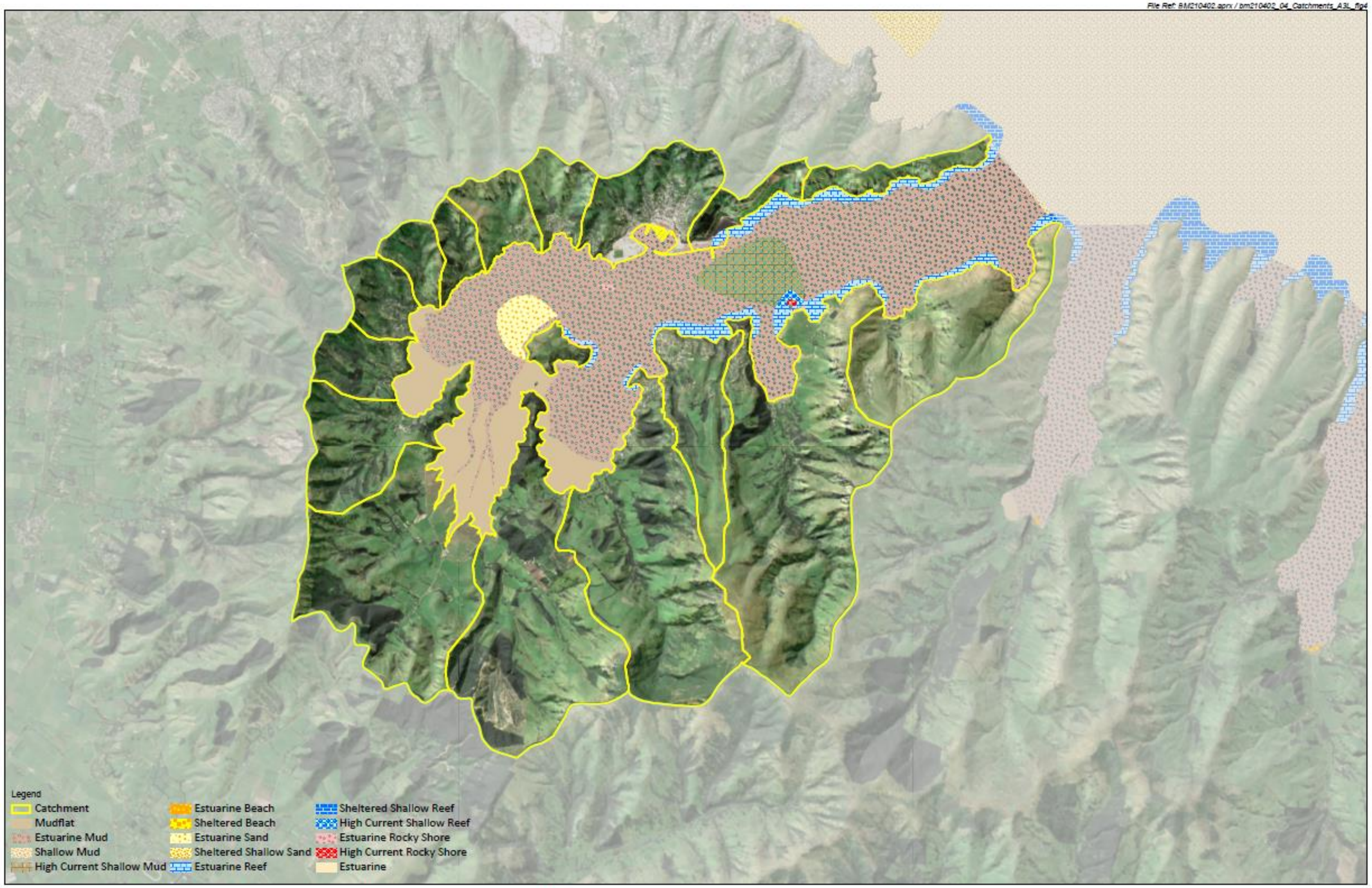
Appendix 1: Harbour coastal margin terrain



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0 1,880 m

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DRAFT

Data Sources: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Projection: NZGD 2000 New Zealand Transverse Mercator

WHAKA-ORA BIOSECURITY STRATEGY

Whaka-Ora Biosecurity Catchments

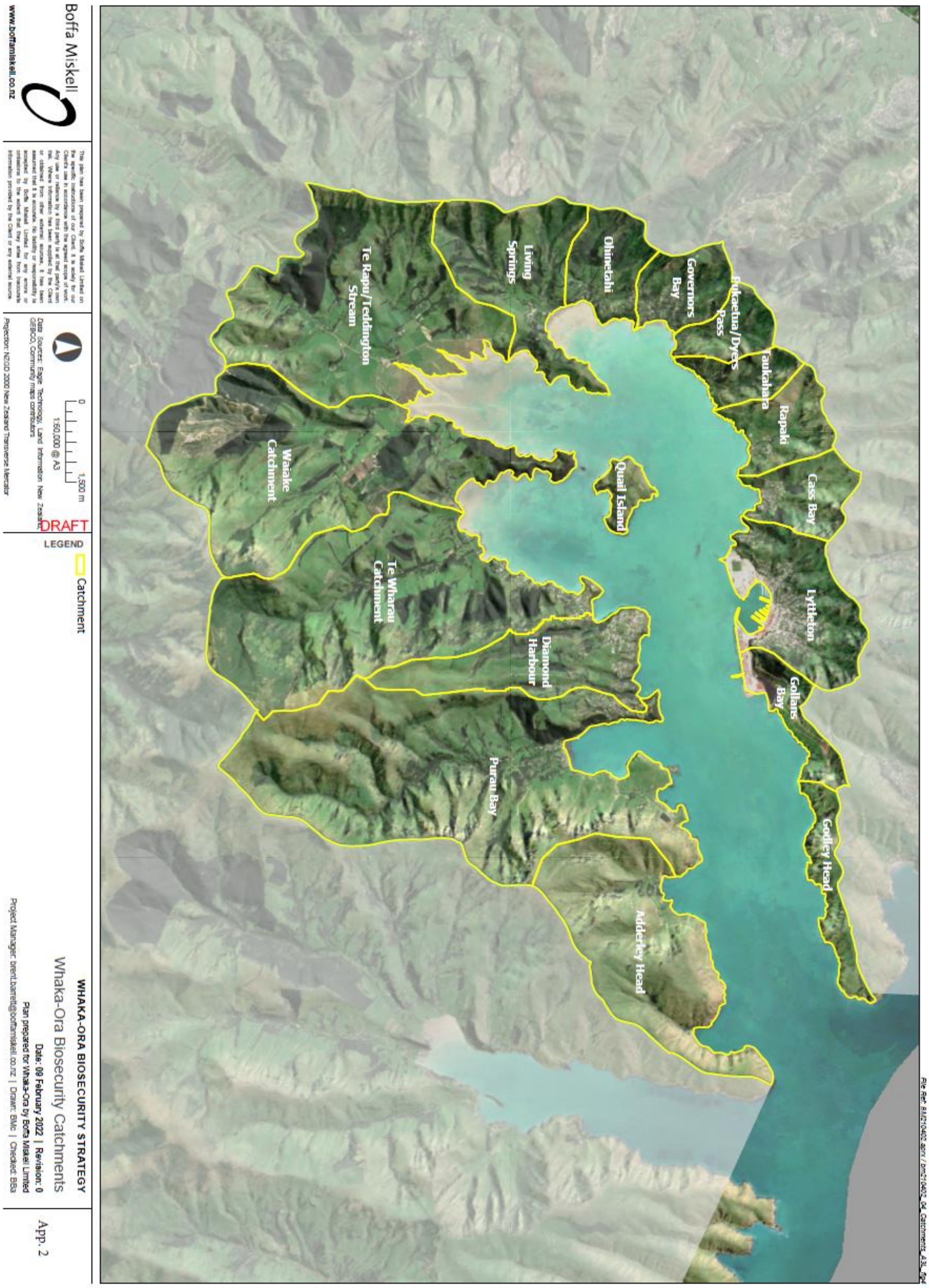
Date: 12 July 2022 | Revision: 0

Plan prepared for Whaka-Ora by Boffa Miskell Limited

Project Manager: brent.barrett@boffamiskell.co.nz | Drawn: BMc | Checked: BBa

App. 1

Appendix 2: 16 catchment delineations



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1:60,000 @ A3
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LEGEND
Catchment
WHAKA-ORA BIOSECURITY STRATEGY
Whaka-Ora Biosecurity Catchments
Date: 09 February 2022 | Revision: 0
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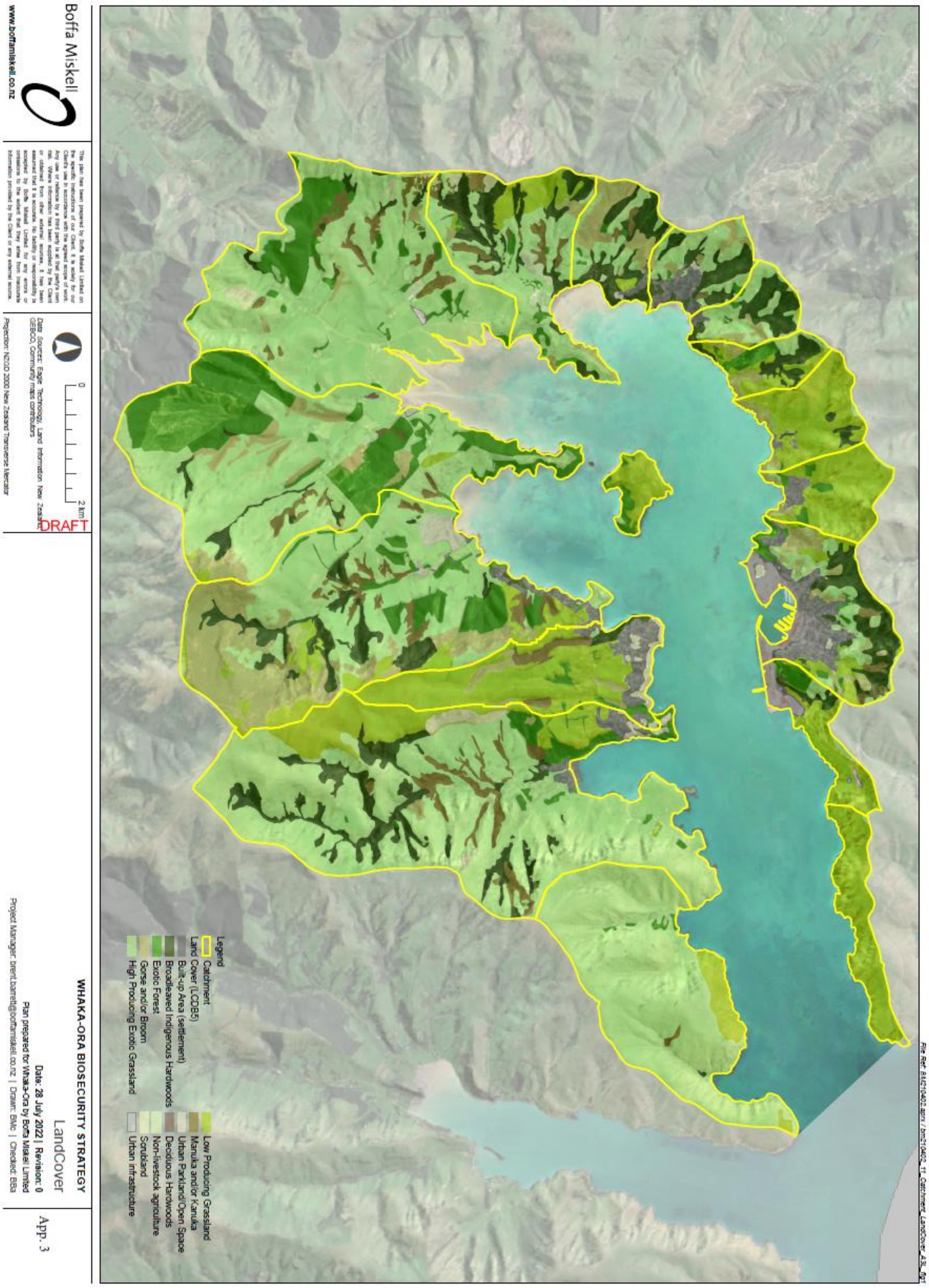
Te Rapu/Teddington Stream
Living Springs
Ohinetahi
Governors Bay
Taukahara
Rapaki
Cass Bay
Lyttelton
Gollans Bay
Godley Head
Quail Island
Waiake Catchment
Te Wharau Catchment
Diamond Harbour
Purau Bay
Adderley Head

Appendix 3: Land-use analysis within each catchment.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2 km
Data Sources: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
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Projection: NZGD 2000 New Zealand Transverse Mercator
Legend
Catchment
Land Cover (LCDB5)
Built-up Area (settlement)
Broadleaved Indigenous Hardwoods
Exotic Forest
Gorse and/or Broom
High Producing Exotic Grassland
Low Producing Grassland
Manuka and/or Kanuka
Urban Parkland/Open Space
Deciduous Hardwoods
Non-livestock agriculture
Scrubland
Urban infrastructure
WHAKA-ORA BIOSECURITY STRATEGY
LandCover
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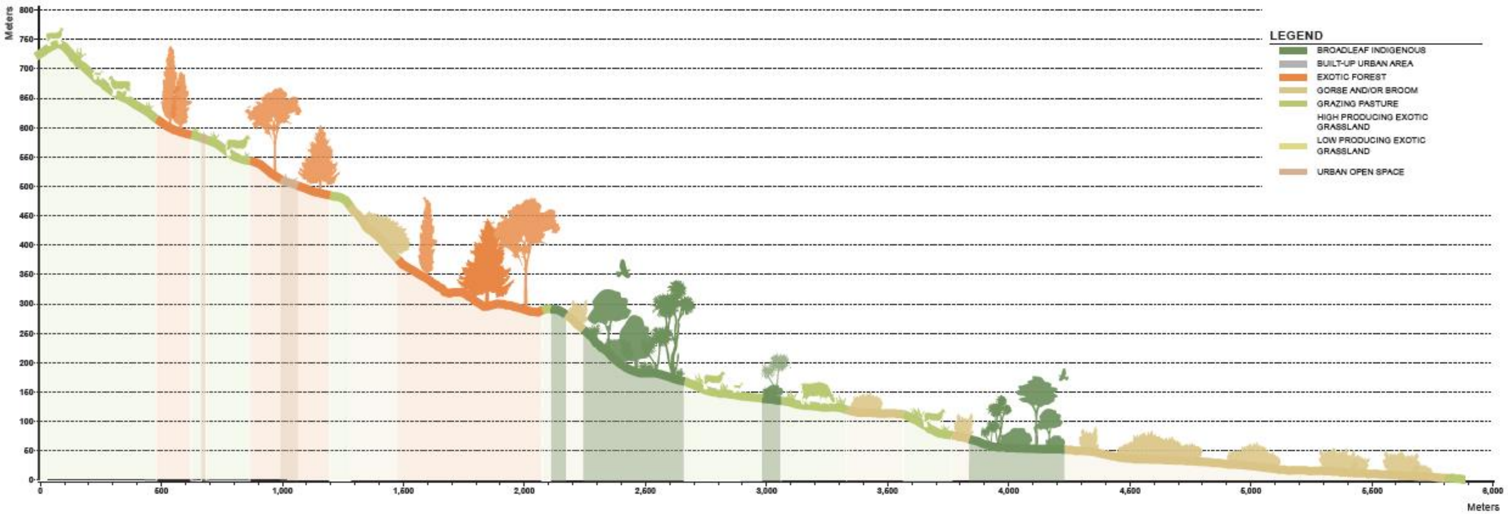
Appendix 4-6: Assessment of land use along catchment rivers

TE WHARAU CATCHMENT

File Ref: BM210402_CatchmentSection.indd

CATCHMENT LOCATION



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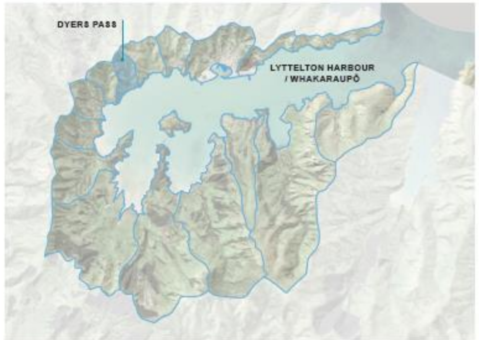
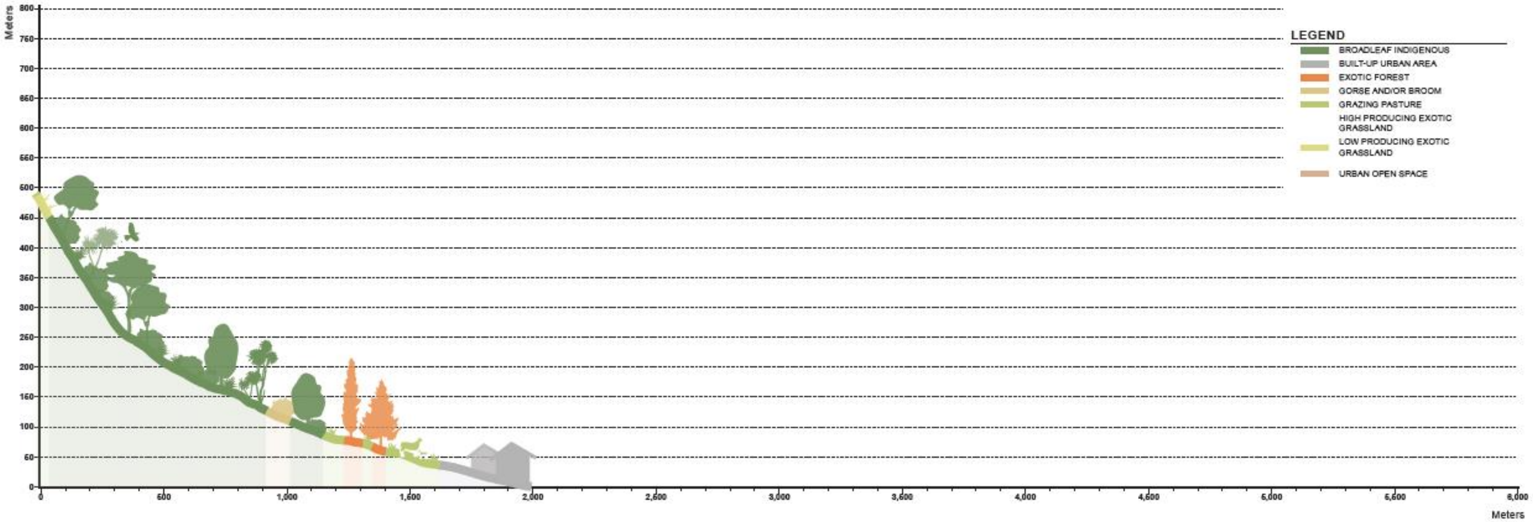
PUKAETUA DYERS PASS CATCHMENT

CATCHMENT LOCATION





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BIOSECURITY STRATEGY FOR WHAKA ORA

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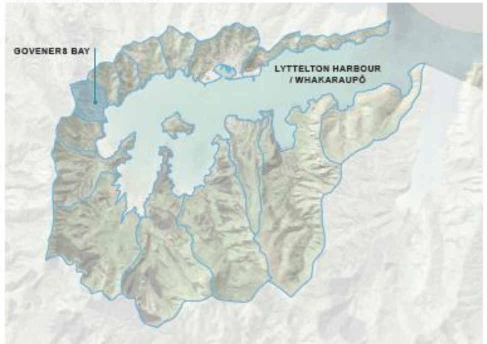
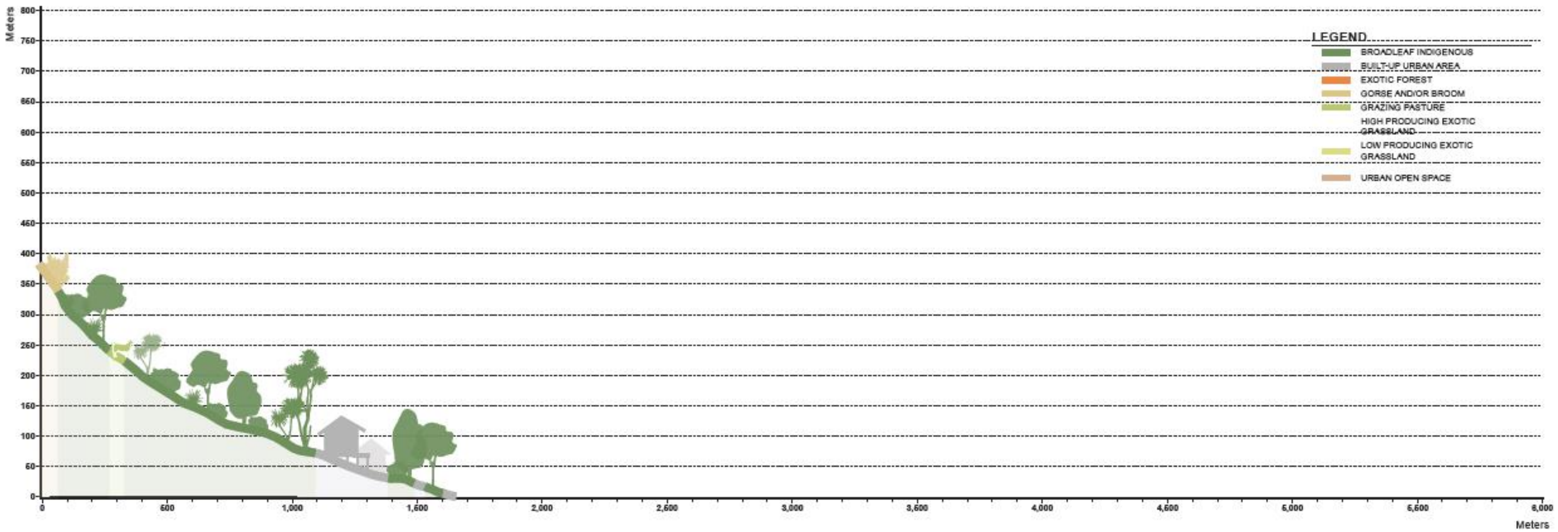
GOVERNORS BAY CATCHMENT

CATCHMENT LOCATION





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BIOSECURITY STRATEGY FOR WHAKA ORA

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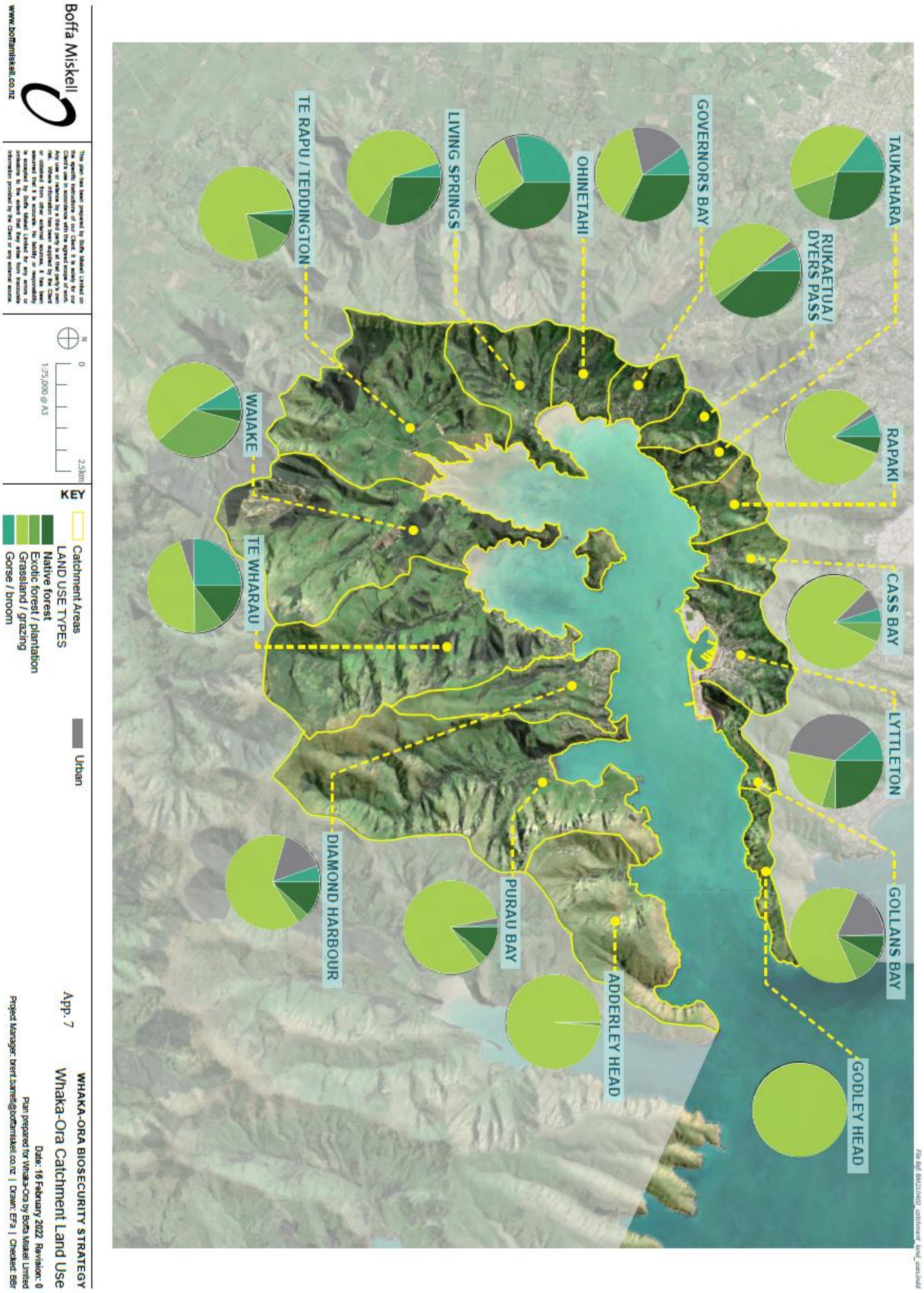
Appendix 7: Pie charts of land use within each catchment.


TAUKAHARA
RUKAETUA / DYERS PASS
GOVERNORS BAY
OHINETAHI
LIVING SPRINGS
TE RAPU / TEDDINGTON
WAIAKE
TE WHARAU
DIAMOND HARBOUR
PURAU BAY
ADDERLEY HEAD
GODLEY HEAD
GOLLANS BAY
LYTTLETON
CASS BAY
RAPAKI
KEY
Catchment Areas
LAND USE TYPES
Native forest
Exotic forest / plantation
Grassland / grazing
Gorse / broom
Urban
1:75,000 @ A3
2.5km
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WHAKA-ORA BIOSECURITY STRATEGY
Whaka-Ora Catchment Land Use
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App.7

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