WHAKAMANA TE WAITUNA

BIODIVERSITY PLAN

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R4701

WHAKAMANA TE WAITUNA BIODIVERSITY PLAN

Wire rush rushland amongst mānuka shrubland, near Waituna Lagoon Road.

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Project Team:
Kelvin Lloyd - Project management
Nick Goldwater - Report author
Carey Knox - Report author
Helen McCaughan - Report author
Steve Rate - Report author
Fiona Wilcox - Report author

Prepared for:
Whakamana te Waituna Charitable Trust

DUNEDIN OFFICE: 764 CUMBERLAND STREET, DUNEDIN 9016
Ph 03-477-2096, 03-477-2095

HEAD OFFICE: 99 SALA STREET, P.O. BOX 7137, TE NGAE, ROTORUA
Ph 07-343-9017; Fax 07-343-9018, email ecology@wildlands.co.nz, www.wildlands.co.nz

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Reviewed and approved for release by:

Kelvin Lloyd
Principal Ecologist
Wildland Consultants Ltd

1. INTRODUCTION

The Whakamana Te Waituna Charitable Trust (the Trust), made of Environment Southland, Southland District Council, Awarua Rūnanga, Ngāi Tahu, Living Water, Department of Conservation and Fonterra have developed a programme of work known as Whakamana Te Waituna that utilises an Integrated Catchment Management approach to:

1. By 2018, a co-governance model arrangement is formalised, operational, has chosen a host organisation and appointed a programme manager,
2. By 2020, we have increased/improved access to land that enables Ngai Tahu to exercise kaitiatanga over their taonga species within the Waituna catchment and lagoon.
3. By 2022, establish a hydrological regime for a healthy lagoon, with recreational and cultural access, that provides adjoining landowners with certainty.
4. By 2022, the area of land managed for biodiversity and ecosystem function accessible for manhinga kai and recreational uses surrounding the Waituna catchment and lagoon has increased
5. By 2022 implement contaminant intervention plan to reduce the rate of sediment and nutrient losses originating from on farm and off farm activities
6. By 2022, community engagement (formal and informal) networks are established/strengthened to enable knowledge transfer approaches, to deliver environmental improvements on and off farm.

The Waituna catchment (Figure 1) includes the Waituna lagoon which forms part of the Awarua wetlands complex and is classified as a wetland of international significance (Awarua-Waituna Lagoon Ramsar site). There is an array of Threatened or At Risk species found around the lagoon and within the wider catchment. This includes both resident and migratory birds, and a diverse array of at risk and threatened freshwater and terrestrial species. Land use in the catchment is mainly agricultural. Three main tributaries flow through the catchment, Carran Creek, Moffat Creek, and Waituna Creek, as well as an extensive drainage network, all of which feed the lagoon. Scattered patches of remnant wetland and forest are found throughout the catchment.

Historically, land clearance, wetland drainage and channel straightening has had an impact on the biodiversity values of the catchment. Introduced plant and animal pests have also had an impact on the varied and unique species found within the catchment. In addition to this, declining water quality in the creeks, drainage network, and lagoon itself negatively impacts on freshwater species.

The catchment has been extensively studied and there is a range of existing biodiversity management programmes in place.

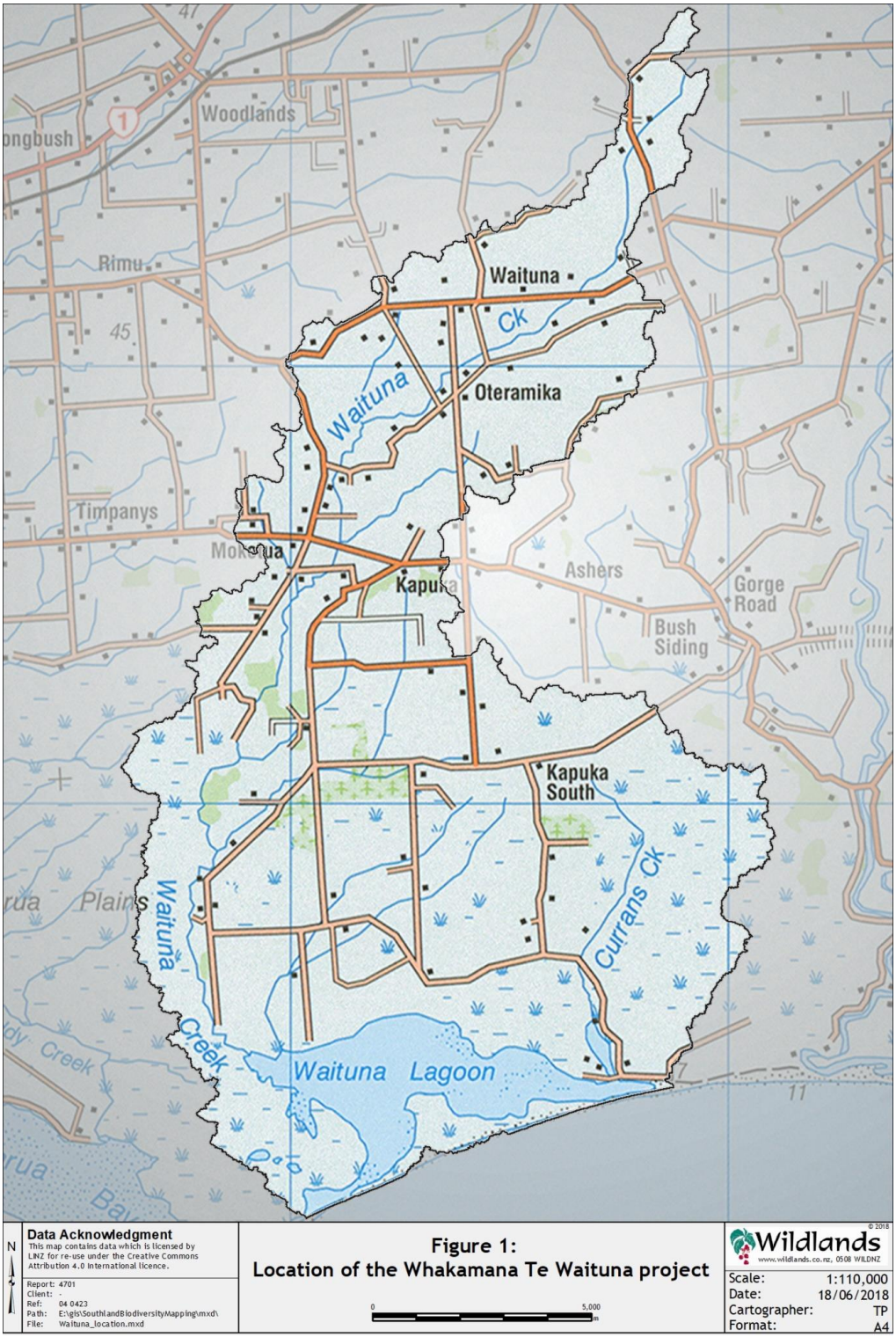
Woodlands
Rimu
Waituna
Ck
Waituna
Oteramika
Timpanys
Ashers
Gorge
Road
Bush
Siding
Kapuka
South
Currans Ck
Waituna
Creek
Waituna Lagoon
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Figure 1:
Location of the Whakamana Te Waituna project
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2. PROJECT OBJECTIVE

The project objective is to:

"Develop a Biodiversity Management Plan that helps Whakamana Te Waituna partners to co-ordinate and collaborate on indigenous biodiversity management within the catchment, to make good management decisions and to protect and enhance the biodiversity values within the catchment."

3. PROJECT SCOPE

The Biodiversity Management Plan for the Waituna Catchment covers all terrestrial and freshwater environments on both private and public land. The plan focuses on the maintenance, protection and enhancement of indigenous biodiversity, but also includes exotic biodiversity if necessary, to support the wider objectives. The priority work identified in this document is intended to help inform work plans going forward but has been developed through a biodiversity lens only. Other factors, such as community and landowner views, costs, and organisational constraints should also be taken into consideration in the development of work plans.

4. METHODS

The following tasks were undertaken to complete the biodiversity project:

- Relevant information, including reports, papers, and environmental monitoring data, was compiled and reviewed.

- Information from the review was used to:
  - Describe the ecological context of the Waituna Ecological District, including it waterways, protected natural areas, and unprotected natural areas.
  - Characterise the vegetation and soils of the Waituna catchment, including terrestrial and wetland habitats, and naturally uncommon ecosystem types.
  - Summarise the current status of biodiversity in the Waituna Catchment.
  - Map the current work programmes (Figure 6).
  - Determine a suitable grouping system to split the catchment into biodiversity management areas (BMAs) based on ecosystem types, management objectives, values and requirements, and map them onto one figure (Figure 6).

- For each Biodiversity Management Area, the following topics were addressed:
  - A brief description including its values, significance to Ngai Tahu and Awarua Runanga, current management, ownership and Whakamana Te Waituna partner involvement (where this information is available).
  - Management objectives (divided into short-term and long-term where appropriate).
  - Characterise the specific threats to the BMAs' values.
  - Outline likely enhancement opportunities for each BMA.
  - Set management targets to manage the threats and enhancement.
  - Provide high level management recommendations to achieve targets.

- Identify potential risks and issues.
- Identify information gaps.

- BMAs were defined to include all significant biodiversity.
- Potential cross-BMA effects and mitigations were identified.
- BMAs were prioritised for management action and management recommendations within each BMA were also prioritised.
- Future risks to the catchment above and beyond those captured in the BMAs were identified.
- Knowledge gaps, where further research/field survey is needed, were also identified.

5. CULTURAL CONTEXT

Wai Parera is the Māori name for Waituna Lagoon. Wai Parera is the body of water where the grey duck was found and collected. Waituna is the main stream flowing into the lagoon where eels are found in abundance. Within this catchment, the various names acknowledge the importance of the past and present association of Iwi with the area. These names reinforce the value of the catchment as both a habitat for flora and fauna and also as a pātaka (storehouse) of mahinga kai (resources).

Nohoanga (settlements) were located in the vicinity of the lagoon. Māori had considerable knowledge of whakapapa, traditional trails, tauranga waka (landings), places for gathering kai and other resources (tāonga).

A great diversity of wildlife is associated with the wetland complex, including several breeds of duck, white heron (kōtuku), gulls, spoonbill, pūkeko, oystercatcher, dotterels, terns and fernbirds. The wetlands are an important kōhanga (spawning) ground for a number of indigenous fish species. Kai available includes giant and banded kōkopu, varieties of flatfish, tuna (eels), kanakana (lamprey), inaka (whitebait), kākahi (freshwater mussel), and kōura (freshwater crayfish). Harakeke, mānuka, tōtara and tōtara bark, and pīngao were also regularly-harvested cultural materials. Paru or black mud was available, particularly sought after as a product for making dyes.

As a result of this history of use and occupation of the area, there are wāhi tapu and wāhi taonga all along its shores. Urupā and wāhi tapu are the resting places of Ngāi Tahu tūpuna and, as such, are the focus for whānau traditions. These are places holding the memories, traditions and values of Ngāi Tahu tūpuna.

Māori had, and continue to maintain, a strong relationship with Waituna. The significance of this tāonga (treasure) to Ngāi Tahu was formally recognised by a Statutory Acknowledgement under the Ngāi Tahu Claims Settlement Act 1998.

6. ECOLOGICAL CONTEXT

6.1 Waituna Ecological District

The Waituna catchment (*c.*20,424 hectares) is located in Waituna Ecological District, which is a relatively small, flat district extending from sea level to only *c.*46 metres above sea level. The Waituna Ecological District retains extensive wetlands and spitbound lagoons and harbours, and is located on Quaternary sediments underlain by extensive Tertiary lignite deposits. It has a smooth and sandy or gravelly coastline (McEwen 1987).

The climate is moist cool temperate, with cloudy and windy conditions and frequent showers. Annual rainfall is 1,000-1,200 mm (McEwen 1987).The ecological district contains a large area of poorly-drained, deep acid peats with strongly leached to podzolised soils on surrounding undulating, rolling, and hilly land that are derived from loess and sands. Some soils have impeded drainage. On coastal dunes and flats, there are areas of sand soils, some with poor drainage. Alluvial soils, which are generally poorly drained, border the Mataura River (McEwen 1987).

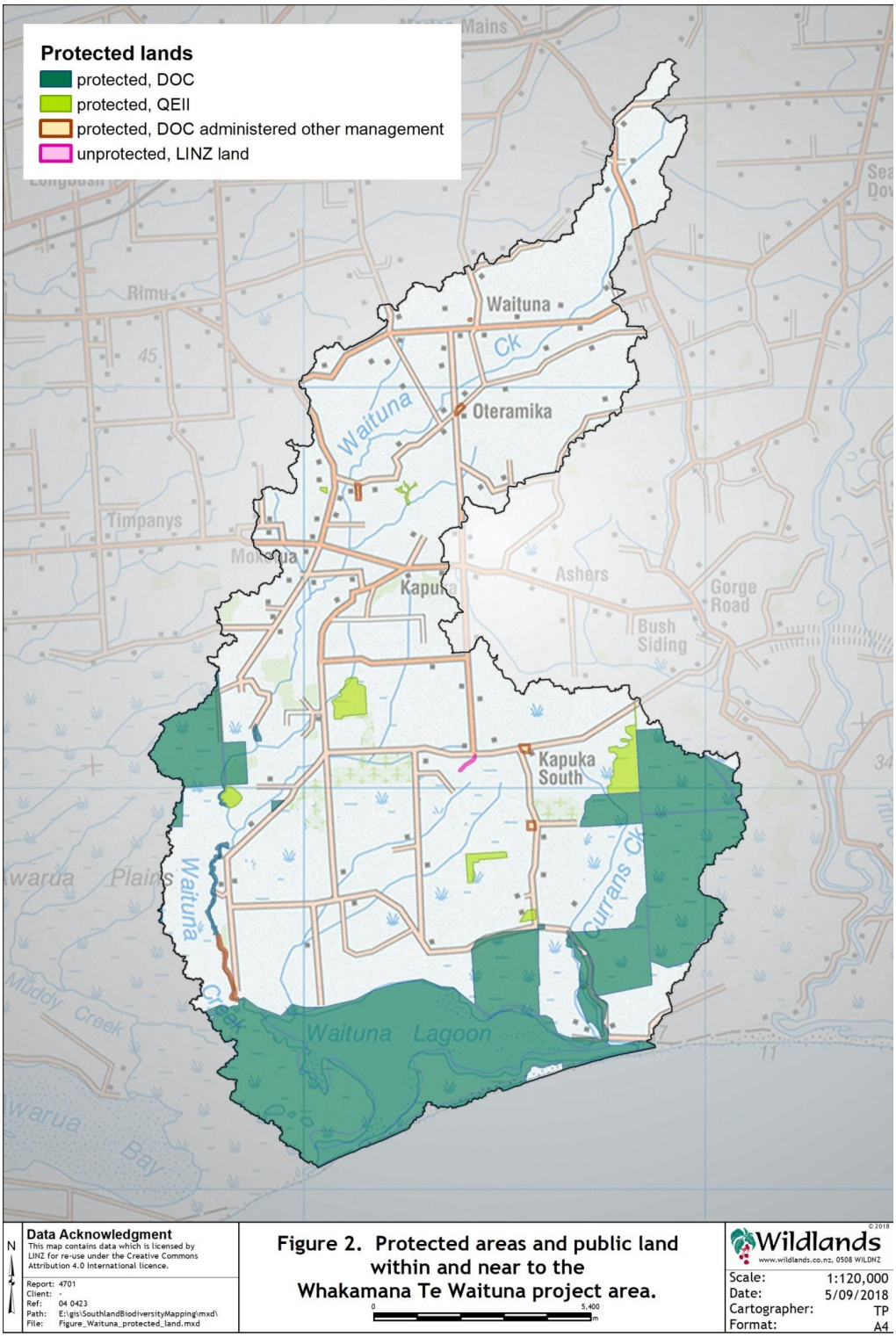
The original vegetation was likely dominated by a mosaic of lowland wirerush (*Empodisma minus*) rushland and mānuka (*Leptospermum scoparium*) shrubland (*c.*60%), and lowland podocarp-hardwood forest (*c.*30%), with minor amounts of coastal tōtara (*Podocarpus totara*) forest, lowland silver beech (*Lophozonia menziesii*) forest, estuarine rushland, coastal pīngao (*Ficinia spiralis*) sandfield, coastal *Pimelea* gravelfield, and coastal herbfield-shrubland (Harding 1999). While extensive areas of peatbog/wetland remain (herbaceous freshwater vegetation covers *c.*12,300 hectares, 24.9% of the Ecological District), much of the original vegetation (particularly forest) has been converted into highly producing, intensively used farmland (*c.*27,360 hectares, 55% of the Ecological District), with areas of exotic forestry covering *c.*1,200 hectares, 2.43% of the Ecological District (LCDBv4.1).

The current natural vegetation mostly comprises peat swamps, with small areas of seral mānuka[1] and flax[2] (*Phormium tenax*), copper tussock (*Chionochloa rubra* subsp. *cuprea*)[3], cushion bogs, and lowland forest remnants[4] dominated by podocarp-kāmahi (*Weinmannia racemosa*) forest. Extensive salt marshes fringe the bays and lagoons, and there is sand dune vegetation along the coast (McEwen 1987). Broad land cover types present in the Waituna catchment are illustrated in Figure 2.

6.2 Waterways

Major waterways present within the Waituna Lagoon catchment are Carran Creek, Moffat Creek, Waituna Creek, and their tributaries. These waterways have been modified by channelisation and straightening, connection to drainage networks, and

[1] 'Mānuka and/or Kānuka' covers *c.*2,020 hectares, 4.09% of the Ecological District. LCDBv4.1.
[2] 'Flaxland' covers *c.*1,190 hectares, 2.41% of the Ecological District. LCDBv4.1.
[3] 'Tall Tussock Grassland' covers *c.*5 hectares, 0.01% of the Ecological District. LCDBv4.1.
[4] 'Indigenous forest' and 'Broadleaved Indigenous Hardwoods' cover *c.*737 hectares, 1.5% and *c.*96 hectares, 0.19% of the Ecological District respectively. LCDBv4.1.


Protected lands
protected, DOC
protected, QEII
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unprotected, LINZ land
Waituna
Ck
Waituna
Oteramika
Timpanys
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Bush Siding
Kapuka South
Waituna Creek
Currans Ck
Waituna Lagoon
Rimu
Plains
Muddy Creek
Bay
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Figure 2. Protected areas and public land within and near to the Whakamana Te Waituna project area.
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ongoing mechanical maintenance works that are still occurring in places. Waituna Lagoon is part of the internationally significant Awarua Plains Wetland Complex, which contains significant waterfowl habitats, important fisheries, habitat for many birds and invertebrates, highly representative and intact peatlands and vegetation sequences, and threatened species (Cromarty and Scott 1995). The lagoon complex is an internationally important wetland, listed under the Ramsar Convention. Carran Creek and Waituna Creek are Type I waters of national importance (WONI) because they feed into the internationally significant Waituna Lagoon and provide habitat for threatened fish. Type I waters are among the most valuable rivers for sustaining New Zealand's freshwater biodiversity (Chadderton *et al*. 2004).

6.3 Protected Natural Areas

Protected natural areas make up *c.*4,958 hectares (*c.*20%) of the Waituna Catchment and are generally located within the southern third of the catchment (Figure 2). Department of Conservation-managed areas cover *c.*4,753 hectares (96% of all protected natural areas, or 18% of the catchment) and Queen Elizabeth II Open Space Covenants (QEII covenants) cover *c.*205 hectares (4% of all protected natural areas, or <1% of the catchment). Ten protected natural areas administered by the Department of Conservation are present within the Waituna catchment: Seaward Moss Conservation Area, Waituna Scenic Reserve, Waituna Wetlands Scientific Reserve, Waituna Wetlands Scientific Reserve (addition), Waghorn Waituna Scenic Reserve, Toetoes Scenic Reserve, Waghorn Scenic Reserve, Waituna Creek Marginal Strip (three parts), Gravel Reserve, and Toetoes Conservation Area.

Seaward Moss Conservation Area, Waituna Scenic Reserve, Waituna Wetlands Scientific Reserve, Waituna Wetlands Scientific Reserve (addition), and Toetoes Scenic Reserve are all part of the greater Awarua-Waituna Wetland complex which contain extensive peatlands with a wide range of intact plant communities. The vegetation of the estuaries and lagoon includes intact sequences of communities from seagrass (*Zostera muelleri* subsp. *novozelandica*) on the mudflats and sandflats to saltmarsh, rushlands, and peatland communities (Directory of NZ wetlands). The major species within saltmarsh and rushland communities include *Samolus repens* var. *repens*, *Selliera radicans*, *Sarcocornia quinqueflora*, *Isolepis cernua*, and oioi (*Apodasmia similis*)) (Directory of NZ wetlands).

Other DOC-managed areas include Waghorn Waituna Scenic Reserve (*c.*311 hectares), Waghorn Scenic Reserve (*c.*240 hectares), Gravel Reserve (*c.*3.9 hectares) and a number of Marginal Strips alongside waterways within the catchment. These areas contain a range of vegetation and habitat types including mānuka shrubland and scrub, peatland, tangle-fern, bog pine, and open water.

Seven QEII covenants are located within the Waituna catchment. QEII Covenant 5/13/024 (64.06 hectares) lies east of Lawson Road. The covenant contains podocarp/kamahi forest, mānuka shrubland, peatland, and extensive open water wetland. QEII Covenant 5/13/256 (32.38 hectares) comprises two blocks west of Waituna Lagoon Road. From satellite imagery, the northern block appears to predominantly contain mānuka shrubland and probably a smaller area of red tussock grassland. The southern block appears to contain broadleaved forest or scrub. QEII Covenants 5-13-217 (1.72 hectares) and 5-13-279 (4.71 hectares) are located near the

western end of Waituna Road and appear to contain podocarp/broadleaved forest, and podocarp/broadleaved species forest and wetland respectively. QEII Covenant 5-13-096 (17 hectares) is just south of Waituna Scenic Reserve, and may contain podocarp/broadleaved species forest. QEII Covenant 5-13-110 (89.18 hectares) borders Toetoes Scenic Reserve and Toetoes Conservation Area and contains a bog with mānuka, wire rush, and tarns.

6.4 Unprotected natural areas

Environment Southland and Southland District Council have undertaken a desktop assessment to identify potential High Value Areas (HVAs) on private land which are likely to contain indigenous biodiversity. Twenty-seven HVAs covering *c.*463 hectares have been identified within the Waituna Catchment. The largest sites are located in the lower third of the catchment within 3-5 kilometres of protected natural areas, the middle third of the catchment contains quite a few sites scattered throughout, with the upper third containing a small number of small sites that are, for the most part, spatially isolated from each other and other protected areas within the catchment. Other unprotected natural areas are likely to be present on private land but have not been identified by the HVA project.

6.5 Threatened land environments

The northern parts of the Waituna Catchment are mostly located on 'Acutely Threatened' land environments with <10% indigenous cover left, while most of the remainder of the project area is located on 'Less Reduced and Better Protected' land environments with >30% indigenous cover left and >20% protected (see Figure 3 and Table 1). The spit separating Waituna Lagoon from the sea is located on 'At Risk' land environments with 20-30% indigenous cover left.

Table 1: Threatened Environment Classifications for privately owned land within the Waituna catchment project area.

Category	Name	Criteria	Area (ha)
1	Acutely Threatened	<10% indigenous cover left	5,564.5
2	Chronically Threatened	10-20% indigenous cover left	
3	At Risk	20-30% indigenous cover left	25.3
4	Critically Underprotected	>30% indigenous cover left and <10% protected	
5	Underprotected	>30% indigenous cover left and 10-20% protected	
6	Less Reduced and Better Protected	>30% indigenous cover left and >20% protected	9,833
-	Unclassified	-	44.74


Environment Classes
< 10% indigenous cover left
10-20% indigenous cover left
20-30% indigenous cover left
> 30 % left and > 20% protected
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Ref: 04 0423
Path: E:\gis\SouthlandBiodiversityMapping\mxd\
File: Figure_Waituna_threatened_environments.mxd
Figure 3. Threatened Environment Classification of the Whakamana Te Waituna project area
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6.6 Vegetation and habitats

6.7 Overview

The Waituna Catchment consists of flat flood plains and gently modulated hills with vegetation cover mostly comprising high yielding pasture grasses for agriculture (*c.*12,863 hectares, 63%) (LCDBv4.1). The natural vegetation within the Waituna Catchment is dominated by wetland vegetation while lowland forest habitats are present as generally small, isolated remnants within the catchment. Forest vegetation has been dramatically reduced through human-induced fires and other forms of vegetation clearance. Other non-freshwater wetland and non-forest indigenous vegetation types are also present within the catchment including gravel beach with herbfield, estuarine vegetation, copper tussock tussockland, and *Coprosma* shrubland (see Table 2 below).

Large areas of indigenous vegetation are present within the lower third of the Waituna catchment, mostly in the southern and eastern parts of the catchment; the middle third of the catchment contains small to medium-sized areas of natural vegetation scattered throughout, with the upper third containing a small number of small sites that are, for the most part, spatially isolated from each other. The remaining vegetation/habitats within the catchment are dominated by exotic species, mainly pasture grasses and associated pasture species (Figure 4).

6.8 Wetland vegetation

Wetland vegetation/habitat types cover *c.*6,901 hectares of the Waituna Catchment with 97% (*c.*6,686 hectares) of this located on public land and 3% (*c.*215 hectares) on private land (MWH 2015). The majority of the wetlands in the catchment are bogs which generally support a cover of mānuka scrub and shrubland and wire rush rushland (MWH 2015), with fen, swamp, marsh, and estuarine/lagoon margin vegetation comprising smaller components (Rance and Crump 2016). Mānuka shrubland and wire rush-tangle fern (*Gleichenia dicarpa*) rushland and fernland are extensive and well-represented within protected and unprotected wetland areas within the catchment. Sphagnum mossland, red tussock (*Chionochloa rubra* subsp. *rubra* var. *rubra*) tussockland, *Carex* sedgeland, and oioi rushland are less extensive but are also well represented in protected and unprotected areas. Minor wetland ecosystems within the catchment include lakeshore herbfield, flaxland, saltmarsh, and cushionfield (see Table 2 below).

Wetland vegetation condition within protected areas is generally good to excellent. In particular, the Waituna lagoon represents an exceptional example of a coastal lake-type lagoon within a largely intact coastal wetland system. The lagoon is home to a *Ruppia*-dominated community not well-represented elsewhere in the country. Shoreline vegetation is largely unmodified, being mainly located within protected areas and includes notable cushion-bog and sand-ridge plant associations (MWH 2015).

On private land, wetland vegetation within surveyed areas is generally in good condition with many sites providing buffers to existing protected natural areas (MWH 2015), however, weeds are common and are a priority for management.

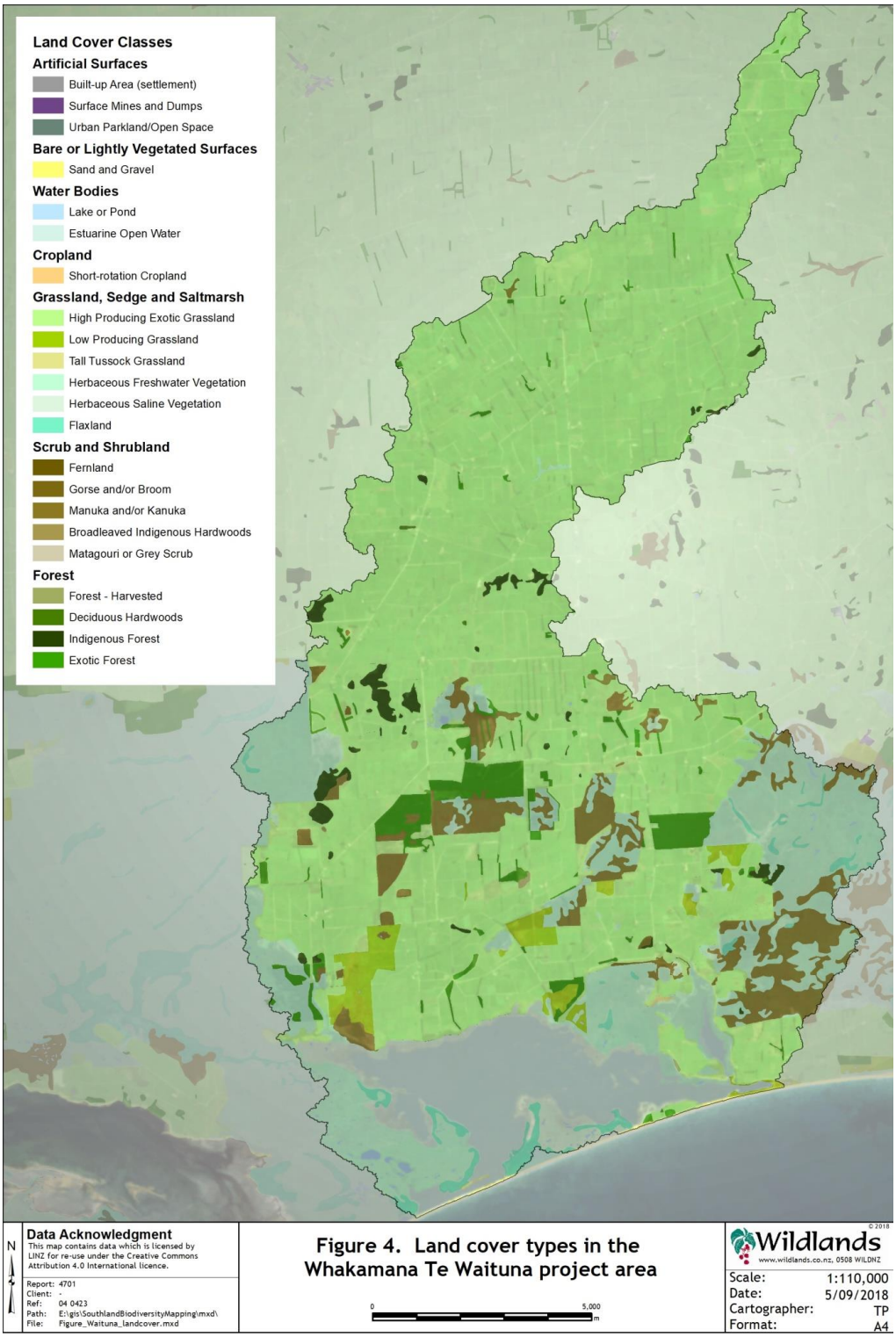

Figure 4. Land cover types in the Whakamana Te Waituna project area

6.9 Terrestrial vegetation

Podocarp-hardwood forest types once covered *c*.30% of the Waituna Ecological District (Harding 1999) and were likely present at a similar extent within the Waituna Catchment. Some of the podocarp-hardwood forest would have occurred on the margins of wetter areas as swamp forest, with the remainder present on slightly higher ground as a terrestrial, 'dryland' type. Forest vegetation is present as scattered small to medium-sized remnants with only poor to moderate connectivity with larger forest remnants outside the catchment. Most forest vegetation within the catchment comprises kamahi forest with variable amounts of kahikatea, tōtara, and matai (see Table 2 below). Many of the smallest remnants are in poor condition due to use for stock shelter and/or due to isolation from seed sources (Burge 2015).

Interpretation of aerial imagery (Google Earth 2018) indicates that natural riparian vegetation within the catchment is a very minor component of the vegetation within the Waituna Catchment. The existing indigenous riparian vegetation is in average to good condition, however in certain segments where there is little or no stock exclusion fencing, there is extensive bank slumping and poor riparian condition (MWH 2015).

6.10 Other vegetation/habitat types

Other ecosystems present include sand dune, gravel beach, and red tussockland (see Table 2 below).

Table 2: Summary of the main vegetation and habitat types within the Whakamana te Waituna project area. Sources: Liquid Fuels Trust Board (1985a), Johnson and Partridge (1998), Boffa Miskell Ltd & Urtica Inc (2010).

Broad Hydroclass	Type	Singers and Rogers Ecosystem Type	Description	Distribution
Terrestrial	Gravel beach	SA4: Shore bindweed, knobby clubrush gravelfield/ stonefield	Former strandlines are dominated respectively by orache (*Atriplex prostrata*), scarlet pimpernel (*Anagallis arvensis*), and Californian thistle (*Cirsium arvense*). Above the influence of lagoon level the rear side and crest of the coastal storm ridge are variously covered with patches or swards of marram grass and clubrush, gravel mat plants such as *Calystegia soldanella*, *Muehlenbeckia axillaris*, and *Sedum acre*, and by patches of gorse.	Lagoon margins. Inland margin of the coastal storm ridge which encloses the lagoon, especially at Walkers Bay and in the eastern arm of the lagoon, and locally at the head of Hansens Bay.
	Gorse shrubland	ES – Exotic scrub	Scattered shrubs or patches	In various habitats

Broad Hydroclass	Type	Singers and Rogers Ecosystem Type	Description	Distribution
	Indigenous podocarp/hardwood forest	MF8: Kamahi, broadleaved, podocarp forest	Common emergents are rimu and kahikatea. Miro is also present. Kamahi dominates the canopy.	Raised ground and riparian areas where drainage is better than surrounding peatland.
	Mānuka-gorse shrubland	VS4: Mānuka scrub	Mānuka, gorse, and coprosmas.	Cutover forest remnants, particularly riparian; previously cleared and drained mānuka bog; plantation forest.
	Pasture grassland	EG – Exotic grassland	Rye grass, crested dogstail, browntop, Yorkshire fog, and white clover.	Grazed pastoral land.
	Podocarp-broadleaved species treeland	MF8: Kamahi, broadleaved, podocarp forest	Typical tree species present include rimu, kahikatea, kāmahi, tōtara, miro, and broadleaf.	Associated with podocarp-broadleaved species forest at most sites, but also isolated examples.
	Shelter belts and plantation forest	EF – Exotic forest	Range of exotic tree species including radiata pine and macrocarpa.	Within and adjacent to pasture.
	Silver tussock and tall fescue grasslands	DN5: Oioi, knobby clubrush sedgeland	Silver tussock (*Poa cita*) and tall fescue (*Festuca arundinacea*) grasslands.	Lagoon margins. Along the top of stable gravel beaches.
Wetland and terrestrial	Copper tussock grassland	VS13: Red or copper tussock tussockland	Copper tussock, scattered rushes, coprosmas, mānuka and gorse.	Well-aerated areas of peatland next to forest and scrub; shallow peat overlying gravels; dried-out peat alongside drains.
			Copper tussock grassland.	Sand on Waituna Lagoon margins.
	Coprosma shrubland	SA2: Searush, oioi, glasswort, sea primrose rushland/herbfield	*Coprosma propinqua* dominates.	Lagoon margin.
	Harakeke swampland	WL18: Flaxland	Harakeke (flax), with mānuka and *Carex* species.	Swamps, fens, some terrestrial sites
Wetland	*Juncus pallidus* and *J. procerus* rushland	WL22: *Carex*, *Schoenus pauciflorus* sedgeland	*J. pallidus* and *J. procerus* within bog; scattered mānuka and coprosmas; other rushes, sedges, pasture grasses, and wire rush.	Previously burnt, cleared, and drained peatlands.
	Carex-dominated sedgeland	WL22: *Carex*, *Schoenus pauciflorus* sedgeland	*C. coriacea* or *C. geminata*	Marsh, rough pasture.
			C. pumila and *C. buchananii*	Lagoon margins. Upper parts of relatively stable gravel beaches, east end of the lagoon.

Broad Hydroclass	Type	Singers and Rogers Ecosystem Type	Description	Distribution
			C. gaudichaudiana, rautahi (*C. coriacea*), and sharp spike sedge (*Eleocharis acuta*)	Lagoon margins. Parts of exposed western shore subject to much wave-disturbance of gravels.
	Drains and ponds	n/a	Fringed by flax, red tussock, and rushes. Aquatic species include jointed rush, floating sweet grass, starwort, duckweed, toad rush, *Isolepis aucklandica*, sphagnum, and sedges	Throughout.
	Juncus edgariae rushland	n/a	*J. edgariae* within pasture dominated by crested dogstail and sweet vernal	Undrained pasture developed on lowland yellow-brown earths.
	Knobby clubrush rushland	DN5: Oioi, knobby clubrush sedgeland	*Isolepis nodosa* locally dominant in small areas	Lagoon margins
	Mānuka shrubland	WL4: Mānuka, lesser wire rush, tangle fern scrub/fernland/restiad rushland **OR** WL6: Lesser wire rush, tangle fern restiad rushland/fernland	Mānuka is the dominant shrubby species. Areas of wire rush and tangle fern.	Widespread on peatland
	Mixed rush-grassland	DN5: Oioi, knobby clubrush sedgeland	Knobby clubrush (*Ficinia nodosa*), silver tussock, creeping bent, *Deschampsia caespitosa*, sweet vernal (*Anthoxanthum odoratum*), Yorkshire fog (*Holcus lanatus*), lotus, *Leontodon taraxacoides*, and mosses, especially *Thuidium furfurosum*.	Lagoon margins. Crests of gravel bars
			The above-mentioned species plus sedges such as *Lepidosperma australe*, rautahi, *C. sinclairii*, and *C. flaviformis*, numerous turf herbs, and copper tussock.	Lagoon margins. Narrow zone where oioi rushland abuts on to scrub.
	Oioi rushland	DN5: Oioi, knobby clubrush sedgeland	Oioi forms dense stands. There are scattered *Plagianthus divaricatus* and *Coprosma propinqua*.	Lagoon margins. Foreshore and inshore zones
	Three square sedgeland	SA3: Glasswort, sea primrose herbfield	Three square (*Schoenoplectus pungens*) often forms pure stands, a few metres in extent.	Lagoon margins. In loose gravels of small bays, fronting the oioi zone, or in muddy parts of the lower shore.

Broad Hydroclass	Type	Singers and Rogers Ecosystem Type	Description	Distribution
.....	Turf communities	SA5: Herbfield [Coastal turf]	*Lilaeopsis novae-zelandiae*, *Selliera radicans*, and *Samolus repens*.	Lagoon margins. In gravelly sites, at relatively low level on the shore
			Mimulus repens, *Limosella lineata*, *Crassula sinclairii*, and *Cotula coronopifolia*,	Lagoon margins. Muddy ground at relatively low level on the shore
			Selliera, *Potentilla anserinoides*, *Isolepis cernua*, *Centella uniflora*, *Triglochin striata*, *Leptinella dioica*, *Hydrocotyle sulcata*, and *H. novae-zelandiae* var. *montana*, and the moss *Fissidens asplenioides*.	Lagoon margins. On slightly higher ground, especially within the oioi zone
			Centella uniflora, *Nertera balfouriana*, *N. setulosa*, *Myriophyllum votschii*, *Viola cunninghamii*, *Lobelia angulata*, *Galium perpusillum*, *G. propinquum*, *Schoenus maschalinus*, *Carex flaviformis*, and *Euphrasia repens*.	Lagoon margins. Higher still, especially near the upper extent of the oioi zone, and in moist ground subject to minimal sediment deposition

6.11 Naturally uncommon ecosystem types

Seven historically rare ecosystem types (Williams *et al*. 2007) have been recorded in the Waituna Ecological District (Rance 2016; Table 3), most of which are present in the Whakamana te Waituna project area. Most of the naturally uncommon ecosystem types present within the Waituna Catchment are present within the Awarua-Waituna wetland complex which is mostly protected via Department of Conservation managed land. However, a small area of cushion bog has been found within an unprotected wetland near the Waituna Lagoon (MWH 2015).

Table 3: Threat status and presence of naturally uncommon ecosystem types (Holdaway *et al*. 2012) recorded in the Waituna project area. A '+' symbol denotes that the naturally uncommon ecosystem type listed is present within habitats present in each partnership area.

Ecosystem Type	Threat Status	Waituna ED	Awarua Ramsar	Arawai Kākāriki	Living Water
Active sand dune	Nationally Endangered	+	+	+	
Stable sand dune	Nationally Endangered	+	+	+	
Shingle beaches	Nationally Endangered	+	+	+	
Ephemeral wetland	Nationally Vulnerable	+	+	+	
Cushion bog	Not threatened	+	+	+	

Ecosystem Type	Threat Status	Waituna ED	Awarua Ramsar	Arawai Kākāriki	Living Water
Blanket mire	Nationally Vulnerable	+	+	+	+
Estuary	Nationally Vulnerable	+	+	+	
Lagoon	Nationally Endangered	+	+	+	+

7. FLORA

7.1 Indigenous species

The flora of the Waituna Ecological District is relatively diverse as a result of the diverse ecosystems present within the District (Rance2016). Four hundred and thirty (430) indigenous vascular plant species including 21 Threatened, At Risk, or notable species have been recorded within the Waituna Ecological District including Nationally Vulnerable grass *Lachnagrostis tenuis* (Table 4). Solely within the Awarua-Waituna Ramsar site there are 20 Threatened, At Risk, or notable species (Rance and Crump 2016). Specifically, within the Waituna Catchment, 15 Threatened, At Risk, or notable species have been recorded.

The presence of bog pine (*Halocarpus bidwillii*) and cushion plants (*Donatia novae-zealandiae, Oreobolus pectinatus, Gentiana lineata*, and *Actinotus novae-zelandiae*) are of particular note within the catchment. Bog pine is uncommon in lowland and coastal Southland while the cushion plants are rare outside of localised areas in the Waituna Scientific Reserve and are usually found in alpine or sub-alpine areas, not near the coast. Most of the notable plant species within the catchment have been recorded from protected natural areas, however, three At Risk species and two notable species have been recorded from High Value Areas (HVAs) on private land (*Coprosma pedicellata*, swamp nettle (*Urtica linearifolia*), tufted hair grass (*Deschampsia cespitosa*), bog pine, and *Donatia novae-zealandiae*) (MWH 2015).

Table 4: Threatened, At Risk, and other notable plant species recorded in the vicinity of the Whakamana te Waituna project area.

Species	Common Name	Threat Classification	Location	Source
Lachnagrostis tenuis	Estuary hair grass	Threatened - Nationally Vulnerable	Waituna wetland	Rance and Crump 2016
Carex litorosa	Sea sedge	At Risk-Declining	Waituna Lagoon	Rance and Crump 2016
Coprosma pedicellata		At Risk-Declining	Waituna Scenic Reserve and other sites	B. Rance plant list data
Deschampsia cespitosa	Tufted hair grass	At Risk-Declining	Waituna Lagoon margins	Johnson and Partridge 1998, Bythell 2013
Desmoschoenus spiralis	Pingao	At Risk-Declining	Awarua wetlands	Rance & Cooper 1997

Species	Common Name	Threat Classification	Location	Source
Euphrasia repens	Creeping eyebright	At Risk-Declining	Waituna Lagoon	Johnson and Partridge 1998
Isolepis basilaris	Pygmy clubrush	At Risk-Declining	Waituna Lagoon	Johnson and Partridge 1998, Bythell 2013
Mentha cunninghamii	New Zealand mint, hihoi	At Risk-Declining	Waituna Lagoon	Johnson and Partridge 1998
Urtica perconfusa	Swamp nettle	At Risk-Declining	Waituna Lagoon margins	Bythell 2013
Zostera muelleri subsp. *novaezelandica*	Eel grass	At Risk-Declining	Waituna wetland	Rance and Crump 2016
Crassula kirkii	Kirk's crassula	At Risk-Naturally Uncommon	Waituna Lagoon	Johnson and Partridge 1998
Ruppia megacarpa	Horse's mane weed	At Risk-Naturally Uncommon	Waituna Lagoon	Johnson and Partridge 1998
Thyridia repens	Native musk	At Risk-Naturally Uncommon	Waituna Lagoon	Johnson and Partridge 1998, Bythell 2013
Raoulia hookeri		Not Threatened. Locally uncommon.		
Halocarpus bidwillii	Bog pine	Not Threatened. Near its southern distributional limit (Cromarty and Scott 1995). Locally uncommon	Bog	
Donatia novae-zealandiae *Oreobolus pectinatus* *Gentiana lineata* *Actinotus novae-zelandiae*	Cushion plant	Not Threatened. Typically upland/alpine species occurring near sea level	Waituna Scenic Reserve	Thompson and Ryder 2003 Old records
Libertia peregrinans				Thompson and Ryder 2003 Old records 1968, 1984
Utricularia sp.	Yellow bladderwort		Waituna Lagoon	Rance and Crump 2016 Thompson and Ryder 2003 *U. dichotoma* is present

8. FAUNA

8.1 Overview

The Awarua Wetlands and lagoon provide important habitat for a wide range of birds, some lizards, and freshwater fauna. A number of fish species are found in the creeks including long and short fin eels, common bully, and giant kōkopu, for which the Waituna catchment is a stronghold (MWH 2015). No indigenous frog species have been recorded from the Waituna Catchment (MWH 2015), although there are anecdotal observations of the introduced brown tree frog (*Litoria ewingii*; (Ron Munroe pers. comm.).

8.2 Birds

The Awarua-Waituna complex of estuaries and lagoons is one of the five most important waterfowl habitats in New Zealand. The site is unrivalled by any other single habitat in Southland for the diversity of species. Of the 81 bird species recorded from the complex, 66 are partially or wholly dependent on the estuarine environment. The wetland complex is particularly important for both international and internal migratory shorebirds. All of these reasons were major factors for the inclusion of the Awarua-Waituna Wetland complex as a Ramsar site (Cromarty and Scott 1995). Although the entire Awarua-Waituna wetland complex is not located within the Waituna Catchment, it is likely that all of the birds recorded from the entire site would utilise habitats within the portion of the complex located within the Whakamana te Waituna project area.

Waituna Lagoon is an important southern overwintering area for New Zealand shorebirds, hosting six of the seven species of indigenous-breeding shorebirds found on the mainland (NZ pied oystercatcher/*Haematopus finschi*, variable oystercatcher/*Haematopus unicolor*, pied stilt/*Himantopus himantopus*, Southern NZ dotterel/*Charadrius obscurus obscurus*, banded dotterel/*Charadrius bicinctus bicinctus*, and wrybill/*Anarhynchus frontalis*; Dowding and Moore 2006). In addition, endemic black-billed gulls (*Larus dominicanus dominicanus*) and black-fronted terns (*Chlidonias albostriatus*) can be found over-wintering at Waituna (Schallenberg and Tyrrell 2006). During the summer period (September-April), the lagoon acts as a summer refuge and feeding area for up to 16 trans-equatorial migrant bird species (Department of Lands and Survey 1984). Five of these migrant waders (Pacific golden plover/*Pluvialis fulva*, ruddy turnstone/*Arenaria interpres*, lesser knot/*Calidris canutus rogersi*, red-necked stint/*Calidris ruficollis* and bar-tailed godwit/*Limosa lapponica baueri*; Dowding and Moore 2006) are considered indigenous to New Zealand.

A significant attribute of the migratory wader population recorded from the Waituna Scenic Reserve is the number of rare species that have been recorded in the reserve. These include Mongolian dotterel (*Charadrius mongolus*), grey plover (*Pluvialis squatarola*), marsh sandpiper (*Tringa stagnatilis*), sanderling (*Calidris alba*), and Asiatic whimbrel (*Numenius phaeopus variegalus*). The wetlands also serve as an important moulting refuge for the New Zealand shoveler (*Anas rhynchotis variegata*). Australasian bittern (*Botaurus poiciloptilus*) and South Island fernbird (*Bowdleria punctata punctata*) are present throughout the Waituna wetland complex. Both

species have been recorded in wetland habitats within several HVAs (MWH 2015) along with a range of common indigenous and exotic bird species.

A list of indigenous and exotic bird species recorded from the Waituna project area is provided in Table 5 below.

Table 5: Indigenous and exotic bird species recorded within the Whakamana te Waituna project area. Threat status as per Robertson *et al*. (2017).

Species	Common Name	Threat Classification
Anarhynchus frontalis	Ngutuparore; wrybill	Threatened-Nationally Critical
Anas superciliosa	Grey duck	Threatened-Nationally Critical
Botaurus poiciloptilus	Australasian bittern	Threatened-Nationally Critical
Charadrius obscurus obscurus	Tūturiwhatu; southern New Zealand dotterel	Threatened-Nationally Critical
Larus bulleri	Black-billed gull	Threatened-Nationally Critical
Chlidonias albostriatus	Black-fronted tern	Threatened-Nationally Endangered
Calidris canutus rogersi	Huahou, lesser knot	Threatened-Nationally Vulnerable
Charadrius bicinctus bicinctus	Banded dotterel	Threatened-Nationally Vulnerable
Anthus novaeseelandiae novaeseelandiae	New Zealand pipit	At Risk-Declining
Bowdleria punctata punctata	South Island fernbird	At Risk-Declining
Haematopus finschi	New Zealand pied oystercatcher	At Risk-Declining
Himantopus himantopus leucocephalus	Pied Stilt	At Risk-Declining
Limosa lapponica baueri	Bar-tailed godwit	At Risk-Declining
Porzana tabuensis tabuensis	Spotless crake	At Risk-Declining
Phalacrocorax carbo	Black shag	At Risk-Naturally Uncommon
Haematopus unicolor	Tōrea, tōrea pango, variable oystercatcher	At Risk-Recovering
Anas rhynchotis variegata	Kuruwhengi; New Zealand shoveler	Not Threatened
Anthornis melanura melanura	Bellbird	Not Threatened
Ardea novaehollandiae	White-faced heron	Not Threatened
Chrysococcyx lucidus lucidus	Shining cuckoo	Not Threatened
Circus approximans	Australasian harrier	Not threatened
Gerygone igata	Grey warbler	Not threatened
Hemiphaga novaeseelandiae	Kereru	Not Threatened
Hirundo tahitica neoxena	Welcome swallow	Not Threatened
Larus dominicanus	Southern black-backed gull	Not Threatened
Mohoua novaeseelandiae	Brown creeper	Not Threatened
Ninox novaeseelandiae novaeseelandiae	Morepork	Not Threatened
Petroica macrocephala macrocephala	Tomtit	Not Threatened
Porphyrio melanotus	Pūkeko	Not Threatened
Prosthemadera novaeseelandiae novaeseelandiae	Tūī	Not Threatened
Rhipidura fuliginosa fuliginosa	South Island fantail	Not Threatened
Tadorna variegata	Paradise shelduck	Not Threatened
Vanellus miles	Spur-winged plover	Not Threatened
Zosterops lateralis lateralis	Silvereye	Not Threatened
Arenaria interpres	Ruddy turnstone	Non-resident; Migrant
Charadrius mongolus	Mongolian dotterel	Non-resident; Vagrant
Calidris alba	Sanderling	Non-resident; Vagrant
Numenius phaeopus variegatus	Asiatic whimbrel	Non-resident; Migrant

Species	Common Name	Threat Classification
Pluvialis fulva	Pacific golden plover	Non-resident; Migrant
Pluvialis squatarola	Grey plover	Non-resident; Vagrant
Tringa stagnatilis	Marsh sandpiper	Non-resident; Vagrant
Alauda arvensis	Skylark	Introduced and Naturalised
Anas platyrhynchus	Mallard	Introduced and Naturalised
Athene noctua	Little owl	Introduced and Naturalised
Carduelis chloris	European greenfinch	Introduced and Naturalised
Carduelis flammea	Redpoll	Introduced and Naturalised
Cygnus atratus	Black swan	Introduced and Naturalised
Emberiza citronella	Yellowhammer	Introduced and Naturalised
Fringilla coelebs	Chaffinch	Introduced and Naturalised
Gymnorhina tibicen	Australian magpie	Introduced and Naturalised
Passer domesticus	House sparrow	Introduced and Naturalised
Prunella modularis	Dunnock	Introduced and Naturalised
Sturnus vulgaris	Starling	Introduced and Naturalised
Turdus merula	Blackbird	Introduced and Naturalised

8.3 Lizards

The Whakamana te Waituna project area contains significant habitats for indigenous lizards (geckos and skinks) on the Southland plains. Four species are known to occur within the project area (Table 6). The southern grass skink (*Oligosoma polychroma*) is the most widespread species, owing to its ability to adapt to rank exotic grass environments as well as sites dominated by indigenous vegetation. Potential habitats for this species include habitat along roadsides and railways, occasionally in gardens, and in wetlands, dunes, and farm paddocks with some ground cover (Jewell 2018). The cryptic skink (*O. inconspicuum*) has a patchy, but widespread distribution, in the Awarua-Waituna wetland system and on Tiwai Peninsula. The Southland form of the green skink (*O. chloronoton*) is also known from the Awarua-Waituna wetland system and Tiwai Peninsula, but anecdotal reports suggest that it is declining rapidly (Jewell 2018). Decades-old reports indicate that green skinks were historically more widespread throughout Southland but they appear to have disappeared from many sites in more recent times.

Table 6: Lizard species present (or potentially present) in the Whakamana te Waituna project area. Threat status as per Hitchmough *et al*. (2016). The likelihood of occurrence for each species is given and their nearest known localities.

Common Name	Scientific Name	Threat Status	Likelihood of Occurrence	Notes	Nearest Known Localities
Southland green skink	*Oligosoma chloronoton*	At Risk-Declining	Likely to occur	Occupies damp areas with dense ground level vegetation, often with rock cover, along creeks, rivers, wetlands, and lake edges. Anecdotal reports suggest this species is in decline across Southland.	Recent reports from Awarua Wetlands and Tiwai Peninsula. Reported from Waituna Wetlands in late 1980's.
Cryptic skink	*Oligosoma inconspicuum*	At Risk-Declining	Known to occur	Prefers damp habitats, usually native, with dense ground cover. Only found in Otago and Southland.	Recent reports from Waituna Wetlands, Awarua Wetlands, and Tiwai Peninsula.
Southern grass skink	*Oligosoma polychroma;* Clade 5	At Risk-Declining	Known to occur	Prefers damp habitats with ground cover, including exotic rank grasses. Habitat generalist. Widespread in Canterbury, Otago, and Southland.	Recent reports from Waituna Wetlands, Awarua Wetlands, and Tiwai Peninsula.
Korero gecko	Woodworthia "Otago-large"	At Risk-Declining	Likely to occur	Common in rocky habitats. Occasionally found in forest or farmland. Hides in crevices or rocks.	Waituna Wetlands (1985 record), Omaui (recent).

Plates 1 and 2: Southland green skinks from the Seaward Moss wetlands. Photographs: Tony Jewell.

Plates 3 and 4: Left: Cryptic skink from Tiwai Point, Right: Southern grass skink.

Plate 5: Korero gecko.

8.4 Aquatic fauna

Several marine, estuarine, and freshwater fish species have been recorded in the Waituna catchment, along with three species of freshwater macroinvertebrate (Table 7). Aquatic fauna known from the catchment include two species classified as Threatened and six species classified as At Risk (Dunn *et al*. 2018; Grainger *et al*. 2014). Photographs of selected species are shown in Plates 6 to 15.

Table 7: Aquatic fauna records in the New Zealand Freshwater Fish Database (accessed July 2018) (●) for waterways in the Waituna catchment, with additional site/species records from Atkinson 2008 (●), Riddell *et al*. 1988 (●), and Chesterfield 2005 (●).

Species	Common Name	Conservation Status[1]	Carran Creek[2] and Tributaries	Moffat Creek and Tributaries	Waituna Creek and Tributaries	Waituna Lagoon	Tarn
Aldrichetta forsteri	Yelloweye mullet	Not Threatened				●	
Anguilla australis	Shortfin eel/tuna	Not Threatened	●	●	●	●	
Anguilla dieffenbachii	Longfin eel/tuna	At Risk-Declining	●	●	●	●	
Arripis trutta	Kahawai	Not listed					
Echyridella menziesii	Freshwater mussel/kākahi	At Risk-Declining	●	●	●		
Galaxias argenteus	Giant kōkopu	At Risk-Declining	●	●	●	●	●
Galaxias fasciatus	Banded kōkopu	Not Threatened	●	●	●	●	
Galaxias gollumoides	Gollum galaxias	Threatened-Nationally Vulnerable	●				
Galaxias maculatus	Inaka/inanga	At Risk-Declining	●	●	●	●	
Geotria australis	Lamprey	Threatened-Nationally Vulnerable			●		

[1] Conservation status for freshwater fish, freshwater invertebrates, and marine fish are from Dunn *et al.* (2018), Grainger *et al*. (2014), and Hitchmough *et al*. (2007) respectively.

[2] Currans Creek (as listed in the NZFFD) was renamed Carran Creek by The New Zealand Geographic Board in 2010.

Species	Common Name	Conservation Status[1]	Carran Creek[2] and Tributaries	Moffat Creek and Tributaries	Waituna Creek and Tributaries	Waituna Lagoon	Tarn
Gobiomorphus cotidianus	Common bully	Not Threatened	●	●	●	●	
Gobiomorphus gobioides	Giant bully	At Risk-Naturally Uncommon	●	●	●	●	
Gobiomorphus huttoni	Redfin bully	Not Threatened	●	●	●	●	
Forsterygion (*Grahamina*) *nigripenne*	Estuarine triplefin	Not Threatened				●	
Leptoscopus macropysus	Estuarine stargazer	Not listed				●	
Paratya curvirostris	Freshwater shrimp	Not Threatened		●	●	●	
Paranephrops zealandicus	Kōura	At Risk-Declining	●	●	●	●	●
Retropinna retropinna	Common smelt	Not Threatened			●	●	
Rhombosolea leporine	Yellowbelly flounder	Not listed				●	
Rhombosolea plebeia	Sand flounder	Not listed				●	
Rhombosolea retiaria	Black flounder	Not Threatened			●	●	
Rhombosolea sp.	Flounder	N/A	●			●	
Salmo trutta	Brown trout	Introduced and Naturalised	●	●	●	●	

The tributary streams (Waituna Creek, Moffat Creek and Carran Creek) of the Whakamana te Waituna project area provide a considerable area of the available habitat for fish species in the catchment. Within the conservation estate and less modified parts of the catchment, aquatic habitats provide sufficient cover for fish with an abundance of riparian vegetation overhang, overhanging banks, and instream macrophytes (Atkinson 2008). In an assessment of tuna/eel habitat quality in the Waituna catchment, Holmes *et al*. (2015) found that riparian habitat in most of the catchment was in average-good condition and in-stream habitat condition for tuna (eels) in the catchment was poor-average. Areas of high quality tuna habitat in the upper Waituna Creek tributaries and in the lower end of Carran Creek were characterised by deep, sinuous run and pool habitat with extensive emergent grasses and overhanging vegetation. Poor habitat in the Waituna Creek mainstem was characterised by excessive fine sediments on and within the stream bed, uniform shallow (0-0.5 m deep) run habitat and little stream edge cover. Instream habitat for invertebrates within the Waituna Creek and tributaries was poor with limited terrestrial input from the riparian zones and stock access to stream margins (slumping) (Pattle Delamore Partners 2016).

Riddell *et al*. (1998) found a low diversity and generally low abundance of benthic fauna in the Waituna Lagoon. A total of nine taxa were found at three sites. The amphipod *Paracorophium excavatum* was found to be the most abundant taxon, followed by the snail *Potamopyrgus* sp. Other taxa present were three worm (annelid) taxa, flatworms (Platyhelminthes: Dugesiidae), and the isopod *Austridotea annectans*. The caddisflies *Oxyethira albiceps* and *Pycnocentrodes* spp. were found at the confluence of Waituna Creek and the Waituna Lagoon. Other invertebrates reported from Waituna Lagoon include pillbox crabs (probably *Halicarcinus whitei*), other unidentified crab species, small marine bivalves (possibly *Austrovenus stuchburyi*), and pipi (*Phaphus australe*) (Schallenberg and Tyrrell 2006).

A stocktake of aquatic ecology undertaken in 2013 found that macroinvertebrate communities within freshwater habitats in the catchment were of relatively poor quality, and were dominated by taxa typically found in slow flowing lowland streams such as amphipods, sandfly larvae, midge larvae, snails, and worms (MWH 2015).

Plate 6: Inaka/inanga (Photo: Greg Byrnes, Te Kōhaka o Tūhaitara Trust).

Plate 7: Giant kōkopu (Photo: Helen McCaughan, Department of Conservation).

Plate 8: Banded Kōkopu (Photo: Department of Conservation).

Plate 9: Longfin eel/tuna (Photo: Anita Spencer, Department of Conservation).

Plate 10: Giant Bully (Photo: Kenny Rose, Christchurch City Council).

Plate 11: Common Bully (Photo: Helen McCaughan, Department of Conservation).

Plate 12: Black flounder (Photo: Robin Smith, Department of Conservation).

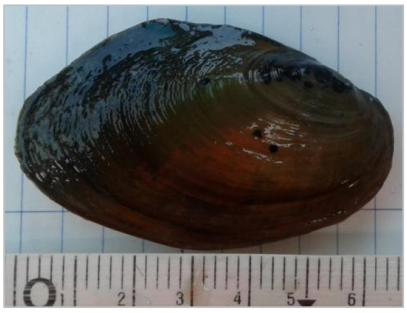

Plate 13: Freshwater mussel/kākahi (Photo Helen McCaughan, Wildlands).

Plate 14: Kōura (Photo: Department of Conservation).

Plate 15: Freshwater shrimp (photo: Helen McCaughan, Department of Conservation).

8.5 Terrestrial invertebrates

The mosaic of wetlands, grasslands, shrublands and sand dunes in the Waituna Lagoon area supports a rich indigenous insect fauna with several distinctive characteristics summarised by Patrick (1983) for the moth and butterfly fauna as follows:

- Usually upland species living at sea-level such as the sphagnum-feeding hepialid moth *Heloxycanus patricki* and wirerush moth *Aponotoreas synclinalis*
- Local endemic species such as the moth *Notoreas casanova*, undescribed boulder copper butterfly *Lycaena* new species and saltmarsh moth *Asaphodes frivola*.
- Many threatened species, particularly moths (Hoare *et al.* 2017) (see list below).
- Many day-flying moths such as *Arctesthes catapyrrha*, *Dasyuris partheniata*, *Aponotoreas synclinalis* and *Notoreas Casanova*, giving the moth assemblage an "alpine" component to it its composition.

Sand dunes and associated dryland communities support many moth and butterfly species of conservation interest including an undescribed boulder copper butterfly (*Lycaena* new species) whose larvae feed on creeping pōhuehue (*Muehlenbeckia axillaris*). Copper tussock-wire rush wetlands are home to an array of species such as the tussock butterfly (*Argyrophenga antipodum*), conspicuous day-flying moth (*Aponotoreas synclinalis*) and tiny primitive moth (*Sabatinca caustic*) whose adults possess jaws, highlighting its ancient pedigree.

Some of these insects are classified as nationally Threatened or At Risk (Hoare *et al.* 2017), including the moth *Asaphodes frivola* (Threatened-Nationally Critical) which occurs in saltmarsh habitat, a new species of the *Pimelea*-feeding noctuid *Meterana* (Threatened-Nationally Endangered), the *Pimelea*-feeding geometrid *Notoreas casanova* (Threatened-Nationally Vulnerable), speargrass-feeding day-flying geometrid moth *Dasyuris partheniata* (At Risk-Declining) and sphagnum-feeding hepialid *Heloxycanus patricki* (At Risk-Declining).

Over 220 indigenous moths and butterflies are known from this area, some of them first discovered and described here so that the area is the Type Locality for these species (Rance & Cooper 1997; Patrick 1983). This includes two day-flying tortricid moths *Merophyas paraloxa* and *Protithona potmias*, both residents of saltmarsh

habitat and who are often seen sunbathing on the stony shore. It is acknowledged, however, that many of the invertebrate records described above are old and the continued presence of all of these species within the catchment is not assured.

9. THREATS TO ECOLOGICAL VALUES

9.1 Overview

The main threats to indigenous vegetation, habitats, plants, and animals within protected natural areas are hydrological modification, pest plants, pest animals, surrounding land-use influences, and sea-level rise. In addition to these threats, unprotected natural areas are also threatened by wetland drainage or modification, indigenous vegetation clearance, lack of buffering, isolation, small size, domestic stock damage, and other land use effects. A summary of the main threats to ecological values within the catchment is presented below.

9.2 Land-based activities

9.2.1 Excessive catchment inputs of sediment, nutrients, and pathogens

Nutrient loads (total nitrogen (TN) and total phosphorus (TP)) and pathogen indicators (*Escherichia coli*) within streams in the catchment are estimated to be extremely high, and contain nutrient and pathogen loads sufficient to place the measured sites within the worst 25% of similar sites elsewhere in NZ (Land Air Water Aotearoa 2018a&b). Mean TN, TP, and *E. coli* concentrations in Waituna Creek exceed the mean values for low elevation New Zealand rivers. Suspended sediment yield from the catchment is estimated to be in the low-moderate range relative to the rest of NZ (Stevens and Robertson 2007). High nutrient levels within waterways in the catchment will have a flow-on effect to downstream receiving environments such as the Waituna Lagoon and associated wetland habitats.

High nutrient levels within wetlands can change vegetation composition and abundance from their natural state to one favouring naturalised species.

9.2.2 Indigenous vegetation clearance

Small areas of indigenous vegetation continue to be cleared to make way for agricultural development (Environment Southland 2017), which have cumulative adverse impacts on local biodiversity. Wetlands on private land that are not legally protected within reserves, conservation covenants (Robertson 2016) or protected by specific statutory regulations (Myers *et al*. 2013) are particularly at risk.

9.2.3 Hydrological modification

<u>Stream and Creek Modification</u>

Modification of streams and creeks within the catchment is continuing through channel straightening, channel deepening, bank re-shaping, bank armouring, removal of instream features, aquatic plant removal, sediment removal, and indigenous

vegetation clearance. These modifications result in a homogenous stream profile, high water velocity, abundant fine sediment, little stream edge cover, and very little habitat for large fish or invertebrates, all of which significantly reduce the available instream habitat for aquatic fauna.

Waituna Lagoon Management

The recent decline in macrophyte abundance (particularly *Ruppia* spp.) (Sutherland *et al*. 2016) has been ascribed to the opening of the Waituna Lagoon during the growing period, which causes beds to be lost through desiccation, wave action, or by bird grazing (Robertson 2007). When the lagoon is closed during the growing period, macrophyte beds flourish, as do algal communities (Stevens & Robertson 2007). *Myriophyllum triphyllum* was previously abundant in some locations in the Waituna Lagoon (Johnson and Partridge 1998), but was not recorded by Schallenberg and Tyrrell (2006) or Stevens and Robertson (2007). Opening of the lagoon may have resulted in the loss of *Myriophyllum triphyllum*, which is relatively intolerant of salinity, or loss of *M. tryphyllum* communities may be due to grazing by birds.

Wetland Drainage

Extensive drainage networks are present within and surrounding peat bogs and other types of wetland within the catchment. Drains affect wetlands by lowering the water table, which provides opportunities for the invasion of exotic species or succession to non-wetland plant communities, and also causes substrate subsidence and loss of organic matter through decomposition, and thus affects the long-term persistence of wetland vegetation. Wetlands are still sometimes drained and converted for agricultural use. Wetlands have also been planted in exotic conifers, which will likely result in their loss. Loss of Southland's wetlands on private land occurs at a rate of about 1.5% per year (Ewans 2016).

9.2.4 Stock

Many areas of indigenous vegetation and waterways are accessible to stock which browse vegetation, prevent vegetation regeneration, damage soil through compaction and pugging, spread weeds, increase bank erosion and sedimentation, and increase nutrient levels in waterways through their excrement and urine.

9.2.5 Other adverse activities

Herbicide spraying, either directly or through wind drift, may adversely affect indigenous habitats. Damage to indigenous vegetation can occur during drain maintenance. Planting of at least one bog with radiata pine has occurred.

9.3 Natural phenomena

9.3.1 Fire

Natural (lightning) and human-induced fires are a relatively rare occurrence, however, recovery of Southland wetlands from fire is slow (Johnson 2005).

9.3.2 Sea level rise

Sea level rise is projected to increase above the existing height regime by the end of the century, resulting in increases in water depth, salinity, and open lagoon time, which are a threat to *Ruppia* habitat and other components of the ecosystem, particularly saltmarsh habitats (Stevens and Robertson 2007).

9.4 Effects at landscape scale

Most of the forest remnants within the catchment are small and lack buffering vegetation which might ameliorate edge effects (i.e. there is a 'hard edge' with pasture). Edge effects (e.g. penetration of light and wind and subsequent changes in microclimate) are likely to be affecting vegetation and habitats, for example through wind damage, increased sites for weed colonisation, and increased effects of pest animals. The shortage of existing forest fragments is the key factor slowing indigenous regeneration within the landscape, and interacts with seed predation and seedling herbivory (Burge 2015).

9.5 Pest animals and plants

9.5.1 Pest animals

Pest animals are a significant threat to indigenous biodiversity values within the catchment. Thirty-seven pest animal species have been identified by Environment Southland as requiring targeted management through the operative Regional Pest Management Strategy (RPMS) (Environment Southland 2013). Of these 37 species, 17 are known to be present within the Waituna Catchment and are significant pests with respect to indigenous biodiversity values (see Table 8 below). It is acknowledged, however, that the RPMS is in the process of being updated and a new strategy is likely to be in place by July 2019. If the proposed strategy is approved, some of the 37 pest animals will no longer be classified as 'pests', noting that feral deer and goats are addressed under the Wild Animal Control Act (1997).

Predators such as rats (*Rattus* spp.), stoats (*Mustela erminea*), ferrets (*M. furo*), weasels (*M. nivalis*) and feral cats (*Felis catus*) are a significant threat to indigenous fauna such as lizards, forest birds, and cryptic wetland birds. Browsing by ungulates such as deer (*Cervus* spp.) and feral goats (*Capra hircus*) threatens indigenous plant populations and can suppress regeneration. Deer are unlikely to be present far from large areas of indigenous or exotic forest. The Department of Conservation aims to have ungulate browsing animals at zero density in the conservation areas and reserves that it manages within the Whakamana te Waituna project area.

Other typical mainland pest animals are also likely to be present including possums (*Trichosurus vulpecula*), mice (*Mus musculus*), weasels (*Mustela nivalis vulgaris*), hedgehogs (*Erinaceus europaeus*), and feral pigs (*Sus scrofa*).

Table 8: Pest animal species which have adverse effects on indigenous biodiversity values, recorded in the Whakamana te Waituna project area.

Species	Common Name	Southland RPMS Status
Capra hircus	Feral goat	Containment
Cervus spp.	Feral deer (wapiti, red, fallow, hybrids)	Suppression
Erinaceus europaeus	European hedgehog	Suppression
Felis catus	Feral cat	Suppression
Lepus europaeus	Brown hare	Suppression
Mus musculus	Mouse	Suppression
Mustela erminea	Stoat	Suppression
Mustela furo	Ferret	Suppression
Mustela nivalis vulgaris	Weasel	Suppression
Oryctolagus cuniculus cuniculus	European rabbit	Suppression
Rattus norvegicus	Norway rat	Suppression
Rattus rattus	Ship rat	Suppression
Sus scrofa	Feral pig	Suppression
Trichosurus vulpecula	Brushtail possum	Suppression

The pest animals present within the catchment affect indigenous biodiversity by consuming foliage, fruit, and seeds of indigenous plant species, preventing indigenous plant species regeneration, and preying on indigenous species of birds, lizards, fish, and invertebrates.

9.5.2 Pest plants

Thirty exotic vascular plant species that are considered pest plants have been recorded within the Waituna Catchment (Table 9). The most widespread pest plants within the catchment are gorse (*Ulex europaeus*), broom (*Cytisus scoparius*), blackberry (*Rubus fruticosus*), elderberry (*Sambus nigra*), Chilean and Himalayan honeysuckle (*Leycesteria formosa*). Of the 30 pest plant species recorded, 20 are subject to legislative action or requirements under the operative Southland Regional Pest Management Strategy (Environment Southland 2013). As for pest animal species, the number of pest plant species will probably change under a new RPMS, which is likely to be in place by July 2019. Pest plants of greatest conservation concern for natural areas are grey willow (*Salix cinerea*), Chilean flame creeper (*Tropaeolum spaciosum*), and Darwin's barberry (*Berberis darwinii*) (MWH 2015).

Chilean flame creeper is of particular concern for shrubland, scrub, and forest habitats because it is a climbing perennial plant which is spread by birds, can spread vegetatively from root fragments, and which tolerates a wide range of growing conditions. Chilean flame creeper can form large infestations within disturbed forest and scrub areas where it can alter light levels beneath the canopy and prevent establishment of indigenous species (Weedbusters 2018a).

Grey willow is of particular concern for wetland habitats because it has a wide environmental tolerance, produces many, widely dispersed, short-lived seeds, which grow rapidly, and can resprout from cut or damaged stems. Grey willow trees can form dense thickets which replace indigenous species in wetlands and can cause blockages, flooding, and structural changes in waterways (Weebusters 2018b).

Darwin's barberry is a particular threat to forest, scrub, shrubland, tussockland, grassland, and herbfield habitats because it is a long-lived plant, with well-dispersed seeds, which tolerates a wide range of growing conditions. The seed is spread via birds and possums and occasional by soil and water movement, and the shrubs can also regenerate via root suckers and layering. Darwin's barberry can form dense stands that replace shrubland and regenerating forest, and can rapidly invade open habitats changing the vegetative composition (Weedbusters 2018c; Waikato Regional Council 2015). The abundance of several terrestrial weed species (e.g. gorse, broom, Spanish heath) is likely to be increasing as a result of improved drainage.

Table 9: Notable weed species recorded in the vicinity of the Whakamana te Waituna project area.

Species	Common Name	Southland RPMS Status
Acer pseudoplatanus	Sycamore	Suppression
Berberis darwinii	Darwin's barberry	Containment
Betula pendula	Silver birch	-
Cirsium arvense	Californian thistle	Suppression
Cirsium vulgare	Scotch thistle	Suppression
Conium maculatum	Hemlock	Suppression
Crataegus monogyna	Hawthorn	Suppression
Cupressus macrocarpa	Macrocarpa	-
Cytisus scoparius	Broom	Suppression
Dryopteris filix-mas	Male fern	-
Erica lusitanica	Spanish heath	Risk Assessment
Eucalyptus sp.	Eucalyptus	-
Hoheria sexstylosa	Lacebark	-
Hypericum androsaemum	Tutsan	Risk Assessment
Ilex aquifolium	Holly	Suppression
Jacobaea vulgaris	Ragwort	Suppression
Leycesteria formosa	Himalayan honeysuckle	Suppression
Lonicera japonica	Japanese honeysuckle	Risk Assessment
Pinus radiata	Radiata pine	-
Populus spp.	Poplar	-
Rhododendron sp.	Rhododendron	-
Rubus fruticosus agg.	Blackberry	Suppression
Salix cinerea	Grey willow	Risk Assessment
Salix fragilis	Crack willow	Suppression
Sambucus nigra	Elder	Suppression
Solanum dulcamara	Bittersweet	Suppression
Sorbus aucuparia	Rowan	-
Taxus baccata	Yew	-
Tropaeolum speciosum	Chilean flame creeper	Containment
Ulex europaeus	Gorse	Suppression

10. SUMMARY OF CURRENT MANAGEMENT

10.1 Overview

Most of the indigenous biodiversity within the Whakamana te Waituna project area is located within protected natural areas managed as part of the Awarua-Waituna wetland complex by the Department of Conservation. The 2014-20024 Southland-

Murihiku Conservation Management Strategy (CMS) has identified the complex and associated protected areas as the 'Awarua Place'. The Awarua Place is identified in the CMS as an ideal location for promoting and increasing awareness of conservation in Southland/Murihiku. A number of community groups and agencies, such as the Waituna Landcare Group, the Whakamana te Waituna trustees, and Community Investment in Water in association with the Department of Conservation and Environment Southland, are working hard to improve the water quality within the wetland complex.

Outside of the protected natural areas, private landowners on their own and in conjunction with the joint Department of Conservation/Fonterra Living Water programme are making headway into protection and enhancement of waterways and wetlands within the catchment. Initiatives for protection and enhancement of forested, non-wetland habitat types are limited within this programme, but the HVA programme has identified a number of these habitats.

10.2 Pest plant and pest animal control

10.2.1 Private land not under QEII covenant

Some private landowners with HVAs on their property undertake pest animal and pest plant control within natural areas on their own properties. Pest animal control usually comprises trapping or bait stations but may also include some shooting of pests. The regularity of control within these areas varies substantially between properties and years as time and resources allow. Applications to the Environmental Enhancement Fund managed by Environment Southland is available for landowners with HVAs on their property for help with pest animal control, pest plant control, and fencing related to their HVAs.

10.2.2 Private land under QEII covenant

Private landowners with QEII covenants on their property undertake pest plant and pest animal control on a regular basis within their natural areas. Pest animal control usually comprises trapping or bait stations but may also include some shooting of pests. Funding is available from QEII to contribute to pest animal and pest plant management as well as other management needs of covenants (e.g. fencing).

A priority possum control area was identified by Environment Southland, Living Water, Department of Conservation, and private landowners which covers the lower Waituna Catchment south of Cook Road, Hodgson Road, and Waituna Gorge Road to the coast. The aim within this area was to reduce possum numbers to less than 5% residual trap catch. Initial control of possums has recently been implemented, resulting in a 1.7% residual trap catch.

The same partnership is planning a mustelid control area but details are not yet published.

10.2.3 Department of Conservation

The Department of Conservation undertakes control of Spanish heath within parts of the Waituna wetland complex, and also controls gorse, Scotch broom, and willows (*Salix* spp.) where required. The Department also undertakes trapping for rats and stoats from Tiwai to the end of Waituna Lagoon, rat trapping around Waituna Lagoon and along the walking track and roads at the eastern end of the lagoon, monitors tracking tunnels in the above areas, controls rabbits (*Oryctolagus cuniculus cuniculus*), controls black-backed gulls (*Larus dominicanus dominicanus*) where they affect other important fauna, and undertakes ungulate pest animal surveillance.

A trapping network is present along the Waituna coast line, which extends east from the trapping network at Tiwai Point and Awarua Bay, to the end of Talls Road and Waituna Lagoon Road east of the lagoon. The trapping line also extends north along Waituna Lagoon Road to the intersection with Hanson Road where it heads west along Hanson Road to a sharp corner at the edge of the wetland. Within this network of traps, thirty-four SA2 feral cat traps are present every 400 metres along the coastline. Eighty-one DOC 200 double traps, and 82 DOC 250 single traps are present within this network and are laid in an alternating pattern every 200 metres within the area of control (Figure 5).

10.2.4 Multi-agency programmes

A priority possum control area (PCA) has been identified by Environment Southland, Living Water, Department of Conservation, and private landowners which covers *c.*6,631 hectares of the lower Waituna Catchment south of Cook Road, Hodgson Road, and Waituna Gorge Road to the coast (Figure 5). The possum control area is primarily under the jurisdiction of Environment Southland, with the aim of reducing possum numbers to less than 5% residual trap catch through establishing a network of bait stations within prime possum habitat on private land. Living Waters is currently funding a mustelid control area although the results are not yet published. There is no feral cat tracking programme in the Waituna Catchment., although Fish and Game Southland is currently undertaking a programme in the wider Southland region (Fish and Game Southland, pers. comms.).

With predator-free 2050 gaining traction at a national political level and grass-roots level within communities, pest animal control within the catchment may become more linked under this umbrella.

10.3 Current monitoring

<u>Environment Southland</u>

Environment Southland undertakes a range of water quality monitoring in Waituna Lagoon and inflowing streams. The Waituna Lagoon is sampled monthly at four sites. Monitoring parameters include: dissolved oxygen (DO), temperature, pH, Chlorophyll-*a*, conductivity, dissolved reactive phosphorus (DRP), ammoniacal nitrogen, total nitrogen (TN), total phosphorus (TP), turbidity, *Escherichia coli*, and salinity. The water level of the lagoon is also monitored.

Monthly sampling is also undertaken at two places in Carran Creek, one location in Moffat Creek, and two locations in Waituna Creek. Monitoring parameters at these sites include: Nitrate-nitrite nitrogen, total nitrogen, total phosphorous, dissolved reactive phosphorus, ammoniacal nitrogen; faecal coliforms, *Escherichia coli*, dissolved oxygen, temperature, turbidity, conductivity, and biochemical oxygen demand* (BOD). Macroinvertebrates and periphyton are also monitored annually at the Waituna Creek monitoring locations.

Department of Conservation

Vegetation monitoring has recently been established in 11 vegetation types concentrating on the most extensive and characteristic types. At least five vegetation plots have been established in each vegetation type with a total of *c.*100 wetland plots established. Wetland monitoring is undertaken using a 10 × 10 metre recce plot methodology, which includes measurement of vegetation cover and height, with soil samples also collected. An additional ten 20 × 20 metre forest plots have also been established. Monitoring within tussock/shrubland, gravel beach, and sand dune has not yet been completed. The monitoring plots will be used to show long-term vegetation change.

The Department of Conservation also undertakes monitoring of threatened plant populations, including *Ruppia* population(s) and swamp nettle (*Urtica perconfusa*), baseline vegetation monitoring of wetland areas, fernbird, bittern, giant kōkopu population monitoring, freshwater fish habitat surveys, and also monitors pest plant and pest animal abundance and spread. Tracking tunnels are used for small pest animal monitoring and are located in all places where traps are deployed. Recent results from tracking tunnels indicate that mustelid populations are low, mice are abundant, rats are present at a moderate density, and cats are common (E. Bardsley, Department of Conservation, pers. comms.).

10.4 Current restoration projects

Arawai Kākāriki Wetland Restoration

The DOC Arawai Kākāriki Wetland Restoration Programme has been working to improve the health of the Awarua Wetland since July 2007. The work has included applied projects and research projects across the lagoon, wetlands, and wider catchment working alongside the community, Ngāi Tahu, and local government. The emphasis of the programme is on wetland restoration, threatened species management, and pest animal and pest plant control and monitoring; however, other actions undertaken as part of the programme include riparian fencing, culvert alignment, riparian planting, farm management assessments, trial constructed wetlands, and nutrient management reporting. Arawai Kākāriki is currently working on finding solutions to largescale wetland forest restoration and has funding for five years of development and trials (J. Bowen, Department of Conservation, pers. comms). Regular monitoring and Environment Southland's State of the Environment reporting has resulted in raised awareness of indigenous biodiversity issues amongst private landowners.

* Measured only at Waituna Creek.

Department of Conservation/Fonterra Living Water programme

Living Water's key focus is designing and implementing a catchment-wide nutrient and sediment management approach to decrease contaminants in fresh water and increase the quality and extent of freshwater habitat. Actions taken under this project that directly relate to biodiversity in the Waituna Catchment include:

- Instream rehabilitation project in progress on Waituna Creek. Instream habitat structures have been installed within the Waituna Creek in the form of log vanes and manuka bundles. It is proposed that these works should be upscaled (Whakamana te Waituna 2018).
- Restoration of wetlands on farms.
- Large-scale riparian planting to reconnect fragmented wetlands, reconnect wetlands and indigenous forest patches, and improve riparian buffering.
- Living Water has also contributed funding to pest animal trapping programmes in the area.

Waituna Landcare Group

- Set up and maintain riparian planting sites around the catchment, using plants from their own plant nursery.
- Restoration of a gravel pit to a wetland with flaxland and shrubland habitat surrounding a central area of open water; provides waterbird and fish habitat. The Gravel Pit Restoration Project mainly involves fencing, planting, and weed control. However a track and lookout have recently been created, water levels have been raised and a fish pass formed to encourage the use of the area by eels and kōkopu, and nest boxes for grey teal have been installed.
- The Landcare Group have a plant nursery where they propagate about 500 plants a year for riparian plantings, along with forest restoration projects in the catchment.

11. BIODIVERSITY MANAGEMENT AREAS

11.1 Overview

Four Biodiversity Management Areas (BMAs) have been identified in the Whakamana te Waituna project area. The BMAs have largely been based on factors such as ecosystem type and current and future management requirements. In some cases, an individual BMA covers multiple sites across public and private land. To summarise:

- BMA 1 encompasses the Waituna Lagoon and adjacent wetland habitats.
- BMA 2 comprises the small dryland forest remnants (privately owned and DOC-administered), most of which occur on private land in the mid to upper

catchment. Also included are smaller areas of wetland vegetation on private land, some of which are protected under QEII covenants.

- BMA 3 comprises all riparian margins, watercourse, and drains, including Waituna Creek, Moffat Creek, and Carrans Creek.

- BMA 4 comprises private agricultural land, excluding areas that are already included in BMA 2 and 3.

11.2 Biodiversity Management Area 1 - Waituna Lagoon and wetlands

11.2.1 Overview

Biodiversity Management Area 1 comprises the Waituna Lagoon and surrounding wetland and shrubland, together with the Waghorn Scenic Reserve in the eastern part of BMA (Figure 6). The Waituna Lagoon is part of the Awarua Wetlands and is one of the best remaining examples of a natural coastal lagoon in New Zealand and unique in Southland and New Zealand (LTG 2013). The significance of the lagoon and its margins was recognised internationally in 1976 when it became a Ramsar site and nationally by gaining Scientific Reserve status in 1983. The cultural significance to the local Ngāi Tahu people was recognised under a Statutory Acknowledgement within the Ngāi Tahu Claims Settlement Act 1998. The lagoon and associated peatlands are identified by the Department of Conservation (DOC) as a priority ecosystem for the conservation of our natural heritage (LTG 2013). The lagoon is also highly valued for its aesthetic appeal, rich indigenous biodiversity, duck shooting, fishing, boating, bird watching, walking, and scope for scientific study.

The lagoon is an important habitat for many species of aquatic fauna, including fish, crustaceans, snails, polychaetes, aquatic insects, and macrophytes (aquatic plants). For fish, the lagoon is an important habitat for (i) spawning, (ii) as a nursery for juveniles (marine and freshwater), (iii) marine wanderers entering into freshwater, and (iv) for species that prefer open water and lake margin habitats. Others, such as giant kōkopu, common and redfin bullies, utilise the network of freshwater systems in the rest of the catchment for most of their life cycles (typically in the adult form). Linkage to the lagoon or the coastal environment maybe vital for the larval stages of these fishes (Atkinson 2008).

Consent conditions permit the lagoon to be artificially opened when the water level reaches two metres during autumn/winter and 2.2 metres during spring/summer. Lagoon opening works are undertaken by the Lake Waituna Control Association, which is made of members of the local rural community. A small digger is used by the group to remove material from the gravel barrier. This artificial regime is implemented to prevent inundation of surrounding low-lying agricultural land (Robertson & Funnell 2012). Prior to human intervention, drainage to the sea is likely to have occurred less frequently, when there was a combination of very high water levels and strong westerlies to cause a break out. These conditions are predicted to have supported prolonged freshwater phases with higher water levels interrupted by sudden opening events (Kirk and Lauder 2000; Cosgrove 2011).

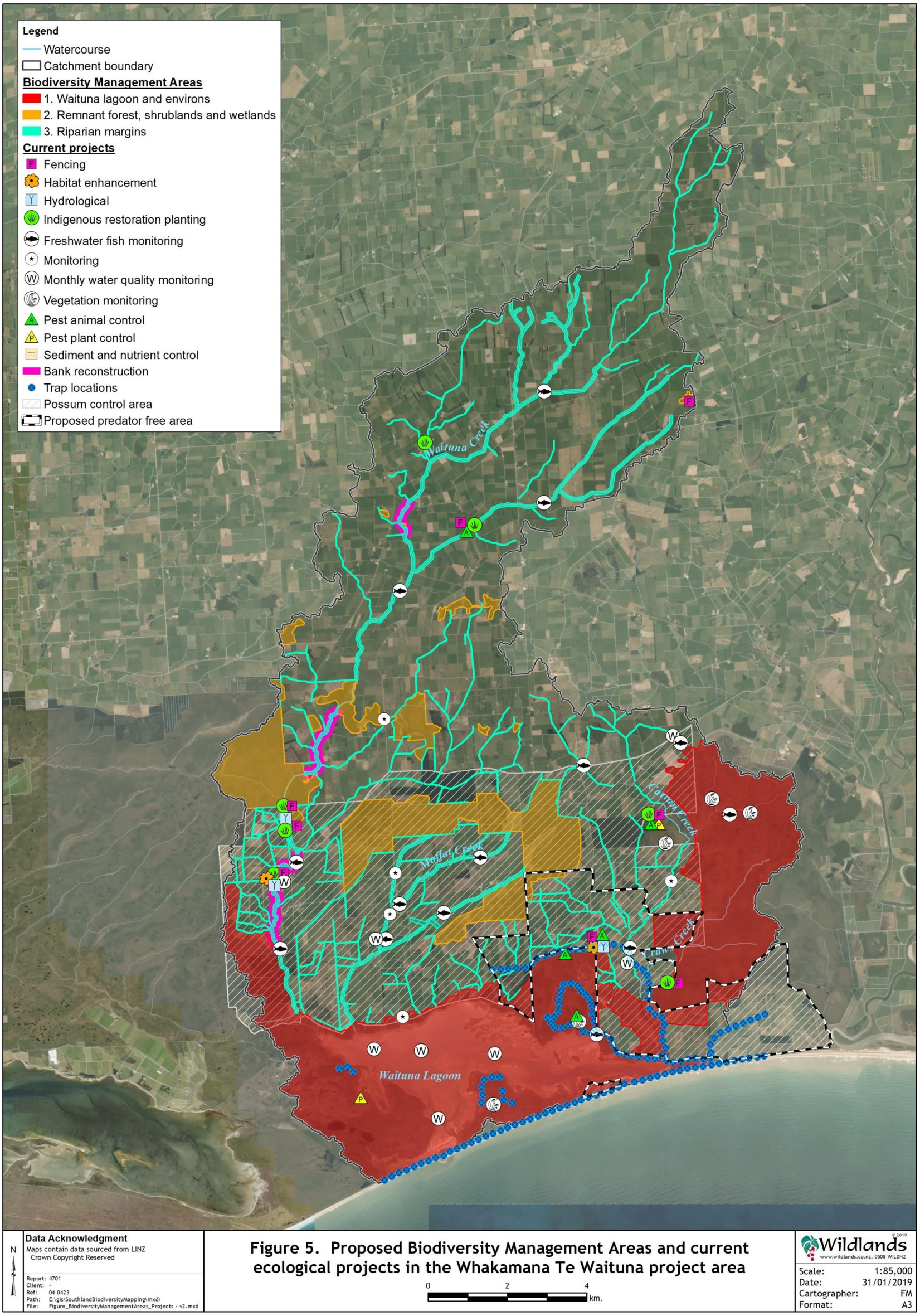

Figure 5. Proposed Biodiversity Management Areas and current ecological projects in the Whakamana Te Waituna project area

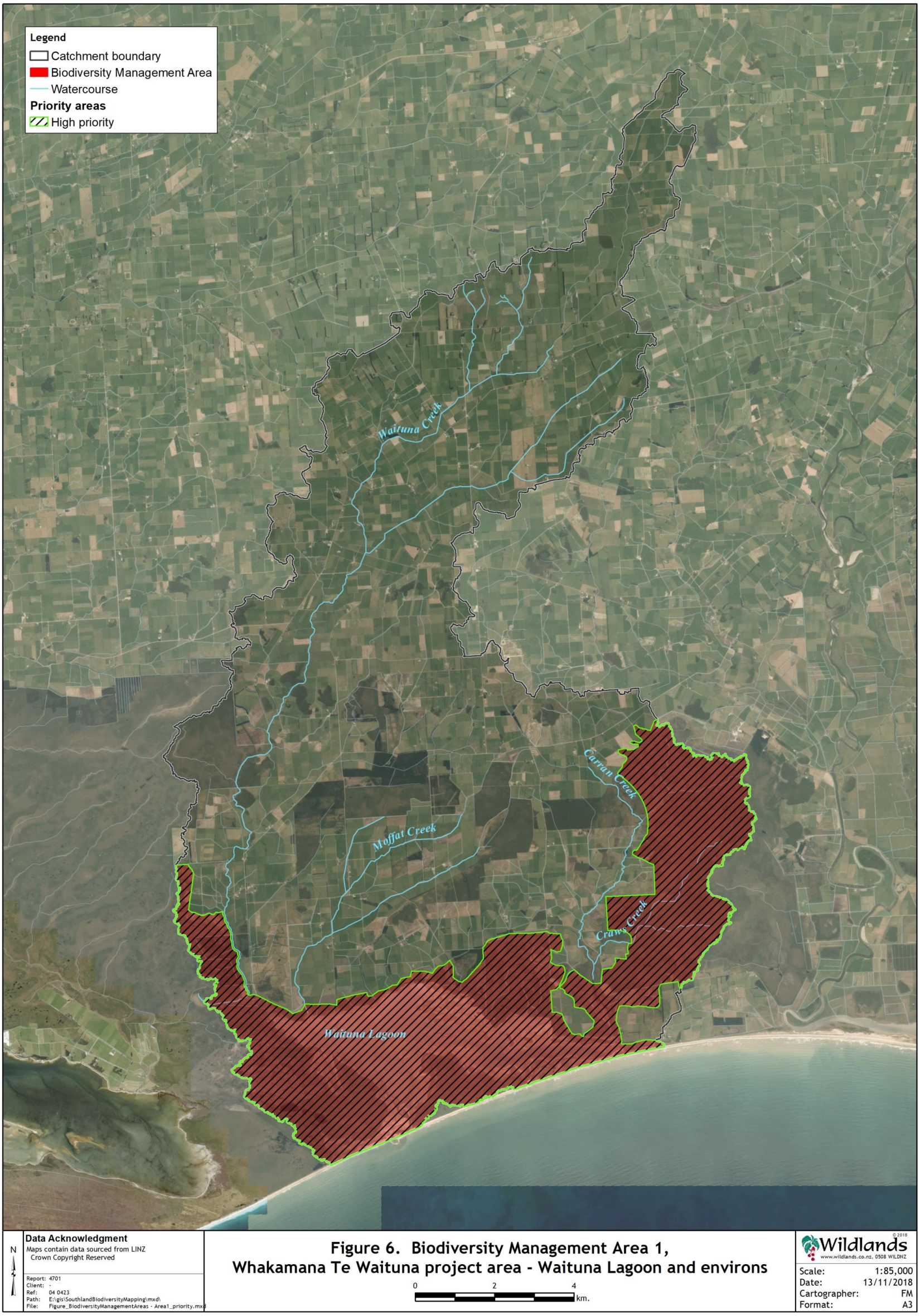

Figure 6. Biodiversity Management Area 1, Whakamana Te Waituna project area - Waituna Lagoon and environs

The Department of Conservation currently undertakes rat and stoat control from Tiwai to the end of Waituna Lagoon. Rabbits are also controlled. Tracking tunnels indicate high abundance of mice, frequent rats, few mustelids, and frequent feral cats.

11.2.2 Specific threats

The lagoon is fed by three lowland streams that flow through agricultural pastures. As a result of increased land-use intensification in the catchment, there has been an increase in contaminant loads entering the lagoon, in particular ammonium and phosphorus (LTG 2013). This has resulted in degradation of the its water quality and the lagoon is now described as being in a eutrophic state, meaning that the lagoon has high nutrients, high phytoplankton biomass and poor water quality (LTG 2013).

Environmental monitoring shows that the water quality in the lagoon and the creeks that flow into it is under stress. As such, the catchment and lagoon require on-going active management to improve their ecological condition. This is to reduce the risk of the lagoon experiencing a 'regime shift', that is, a change from having clear water and an aquatic environment dominated by aquatic macrophyte plants such as *Ruppia*, to one which has turbid and murky water dominated by algal slime and other suspended phytoplankton. More recent work has shown how the different soil types in the catchment impact upon the nutrient loads from productive agricultural systems, and the sources of sediment to the lagoon e.g. bank erosion (Strategy and Action Plan for Waituna 2015).

Over the last 15 or so years, plant species that characterise a healthy lagoon environment have reduced in abundance and been replaced by species that are more commonly associated with enriched and degraded systems (e.g., slime algae; LTG 2013). Based on scientific evidence, if the catchment inputs remain as high as they are now, and lagoon openings are ecologically ill-timed, then the risk of Waituna Lagoon shifting to an algal dominated system will remain high (LTG 2013). This would endanger the *Ruppia* community and change the fundamental values and character of the lagoon. Such rapid shifts have occurred in other lagoons (e.g., Lake Ellesmere/ Te Waihora) leading to the loss of fisheries and birdlife, as well as cultural and recreational values (LTG 2013).

Sedimentation is a significant threat to the ecological and recreational values of Waituna Lagoon. The lagoon is estimated to be infilling with sediment at a rate approximately 10-fold greater than pre-European times (Cadmus 2004).

Climate change-related factors such as increased rainfall intensity and sea level rise also threaten the ecological integrity of the Waituna Lagoon (see Section 13 - Future Risks to the catchment). More frequent droughts brings with them the prospect of increased fires, which in turn can provide an opportunity for gorse to become more abundant, and to gain a greater foothold around the lagoon shores as well as on the peatlands in general (Johnson and Partridge 1998).

Mammalian predators such as stoats, cats and rats threaten indigenous fauna that reside in and around the lagoon. Vulnerable fauna species include fernbird, bittern, dotterels, and lizards. Feral ungulates (goats, pigs, and deer) are present in the area at low levels, although they have not yet established permanent populations.

Ungulates and stock place considerable pressure on threatened plant species as *Coprosma pedicellata*, which is known from the margins of the lagoon. Seedlings are very vulnerable to browsing, and animals can on occasion destroy subadults and adult specimens through bark stripping (NZPCN 2018a). Similarly, the threatened indigenous grass species tufted hair grass (*Deschampsia cespitosa*) is highly palatable to stock and feral ungulates. It is believed that grazing and trampling by cattle is the chief cause of decline (NZPCN 2018b). Low-growing plant plants such as *Donatia novae-zealandiae* and swamp nettle are vulnerable to trampling by stock and feral ungulates.

There is little information on the suite of pest plant species that are present around the lagoon, although the report prepared by MWH (2015) identifies grey willow (*Salix cinerea*) as a key species of conservation concern for Waituna. Grey willow seeds are easily dispersed by the wind; juveniles can invade intact wetland systems and ultimately form a dominant canopy (e.g. Whangamarino wetland in the Waikato).

11.2.3 Objectives for Waituna Lagoon

The Waituna Lagoon Technical Group (2013) recommends a long-term ecological health objective for the lagoon that is based on a stable and self-sustaining indigenous macrophyte (aquatic plant) population. The macrophyte *Ruppia*, in particular, has been identified as being critical to the health of the lagoon for the following reasons:

- absorbs nutrients and stabilises sediment by reducing turbulence
- maintains clear water by reducing sediment re-suspension
- oxygenates the sediments, preventing phosphorus from being recycled
- limits shoreline erosion
- provides habitat and food for aquatic species (fish, macroinvertebrates, birds)

Pest plant and animal species pose significant threats to the values of this BMA. Controlling predators such as feral cats, stoats and rats is critical for protecting and enhancing threatened indigenous species such as Australasian bittern, South Island fernbird, and black-billed gull. Pest plants can out-compete indigenous wetland species and significantly alter the character of the natural system.

It is acknowledged that the Department of Conservation is currently carrying out predator control throughout the lagoon and adjacent wetlands.

11.2.4 Potential opportunities for restoration

Managing nutrients is pivotal to restoring the ecology and Mauri of the lagoon. Modelling scenarios undertaken by the University of Waikato indicated that high *Ruppia* and low slime algae could only be achieved with a combination of nutrient load reduction and continued use of mechanical openings (Hamilton *et al*. 2012). Keeping the lagoon closed but decreasing nitrogen and phosphorous inputs by 50% resulted in an increase in *Ruppia* levels, but algal levels were still high. Regardless of the lagoon opening regime, it is unrealistic to achieve such a reduction in nutrient loads in the short to medium term, i.e. within a timeframe that could see an irreversible regime shift in the lagoon.

11.2.5 Prioritised management targets and high level recommendations to achieve targets

All of the recommendations outlined below are high priorities for action within the Waituna Lagoon and, given unlimited funding, would be undertaken concurrently. However, given that funding and other resources are finite, the recommendations have been prioritised based on the most pressing need, simplicity of instigation, and which actions will deliver good, multi-target outcomes for limited effort.

Priority 1 - Fencing to Exclude Stock from Wetlands and Lagoon Shore

- Excluding all domestic stock (cattle, sheep, goats, and deer) from the BMA will improve the biodiversity and water quality within the BMA, as well as ease pressure on threatened plant communities.
- This action is the highest priority for management because it is a relatively simple solution that can be implemented in the short term, and will go a long way towards achieving gains towards improving water quality and maintaining and enhancing biodiversity values.

Priority 2 - Prevention of Regime Shift

Management interventions should be undertaken to prevent an irreversible regime shift in the lagoon. This is a high priority as prevention of a regime shift will be less costly and time consuming than attempting to remediate the lagoon following a regime shift. This recommendation is only secondary to the fencing recommendation above due to the complexity involved in implementing the following recommendations. The following targets and recommendations are taken from a report prepared by the Waituna Lagoon Technical Group (2013):

- Set a target of >30-60% cover of *Ruppia* and other indigenous macrophytes (based on average annual % cover at permanently wetted sites). This target is based on international research (e.g. Jeppesen *et al.* 1994; Blindow *et al.* 2002; Kosten *et al*. 2009), and it is acknowledged that a recent review suggested 50% coverage as a conservative level to ensure a clear water state. In recent years, cover in Waituna Lagoon has fallen well short of 50% (LTG 2013). To achieve this objective, it is recommended that specific nitrogen and phosphorus loading rates are set to the lagoon and establishing a lagoon opening regime that is consistent with the objective (see below).
- The recommended catchment nutrient loading rates required to achieve the proposed macrophyte target are <125 tonnes/year for nitrogen (a lagoon aerial loading of <90 kg N/ha/yr) and <7.7 tonnes/year for phosphorus (a lagoon aerial loading of <5.7 kg P/ha/yr). This is approximately a 50% reduction in current

loading rates[1]. This aspect of the lagoon management will be dealt with through the contaminant intervention being undertaken by…

Comment [NG1]: Jane to provide details.

- Work towards a long-term consent for lagoon opening that continues to build on recommendations in the LTG and to give the catchment certainty of lagoon management beyond 2022. It is important that the timing of future lagoon openings takes into consideration the keystone aquatic vegetation community (i.e. *Ruppia*). Spring is when *Ruppia* seed germination mainly occurs and high salinity during this time inhibits Ruppia germination. In addition, Ruppia flowering and seed production is negatively affected by the lagoon being open to the sea during summer because the amount of *Ruppia* habitat is severely constrained by low water levels.

Priority 3 - Pest Plant and Animal Control

- Aim for complete eradication of feral ungulates, given that they have not yet established in the area. Prioritise protection of areas that support known populations of threatened plant species.
- Control possums, rodents, hedgehogs, and mustelids within a buffer zone (*c.*150 metres wide) along the landward (northern) margin of Waituna Lagoon. This will complement existing trapping along the southern coastline and help reduce reinvasion from adjacent farmland.
- Aim for complete eradication of grey willow, Spanish heath2 and gorse from margins of lagoon and adjacent wetlands. Consider using drones to surveys wider wetland for new incursions of pest plants.

Priority 3 - Monitoring of Threatened Plant Species

- Identify and map key populations of threatened plants using permanent photopoints and/or permanent RECCE plots.
- Undertake baseline monitoring using permanent plots and/or photopoints to measure future changes in populations.

Priority 4 - Migratory Fish

- Ensure that the needs of migratory fish are considered when lagoon openings are scheduled, i.e. eggs of diadromous species are able to reach the sea and juveniles have unimpeded access to streams during upstream migration.

11.2.6 What does success look like?

The following performance measures have been adapted from the Strategy and Action Plan for Waituna (2015):

[1] The recommended catchment loads are not intended as broad brush reductions across the whole catchment, or for all farm land in the catchment, but rather as reductions in the amount of nutrients reaching the lagoon (LTG 2013).

Kaitiakitanga

- Reinforcing the strong relationship between Ngāi Tahu (Awarua Rūnanga) and their culture and traditions with their ancestral lands, sites, waahi tapu and other taonga, and the exercise of kaitiakitanga.

Healthy Catchment and Lagoon

- Healthy lagoon and wetland ecosystem in which the flora and fauna, for which the Awarua-Waituna is renowned for and recognised under Ramsar, flourish.
- Abundant and healthy rooted aquatic and wetland plant community in the lagoon, particularly species of *Ruppia* but also wiwi and harakeke (flaxes).
- A regime shift from an aquatic plant dominated system to an algal-dominated eutrophic system in the lagoon has been prevented.
- Catchment and lagoon in such a healthy state that they no longer require the focused intensive attention they currently receive; the focus shifts to sustaining their values and appreciating the positive relationship which exists between the community and the environment in which the community lives.
- The nutrient and sediment loads to the lagoon are reduced and an opening/closing regime managed so that the lagoon will display some eutrophic conditions rather than be a pristine environment, but will still support healthy macrophyte and fish communities

Biodiversity

- Abundant and healthy indigenous fish, plant, invertebrate, reptile and bird populations; protection of wetlands in the catchment as refuges of biodiversity and for the ecosystem services they provide; and lagoon, stream, and wetland ecosystems thrive and support indigenous biodiversity.
- Reduced competition from pest plants has allowed indigenous species to establish and flourish; gaps created following pest plant control have been colonised by indigenous wetland plants.

Agreed Lagoon Levels

- Agreed water level management regime for the lagoon which provides for all the values of the catchment.

Mahinga kai

- Abundant and healthy mahinga kai including: strong kokopu, patiki (flounder), tuna, kanakana (lamprey), waikoura (freshwater crayfish) and inaka (whitebait) populations; a diversity of life as part of a healthy ecosystem; and maintaining healthy recruitment/replenishment of these from the mountains to the sea (ki uta ki tai).

Healthy Streams

- Improved water quality and in-stream habitat will benefit aquatic fauna and enhance recreational values.

11.2.7 Potential risks and issues

Human-induced changes in the frequency of coastal lagoon opening may disrupt ecological functioning by inhibiting critical life-history phases such as germination of aquatic plants (Nicol 2005; Viaroli *et al*. 2008). For example in the Waituna Lagoon, a sudden increased saline influence could adversely impact species such as *Ruppia* and charophytes (Robertson and Funnell 2012). It is also important to note that *Ruppia* are obligate aquatic plants and will desiccate rapidly if exposed to the air (Brock 1982; Nicol 2005), i.e. through lowering the lagoon water level. The decline in *Ruppia* site occupancy from 69 % in 2009 to 23 % in 2011 is largely attributed to the prolonged period of salinity during key life cycle stages, and the increase in bed exposure from low water levels (Robertson and Funnell 2012).

11.2.8 Information gaps and priorities for field survey

The Waituna Lagoon system is highly complex. Over the last few years there has been significant investment by various parties to develop a greater understanding of the catchment and lagoon. While the level of knowledge has improved dramatically, some of the causes of the water quality decline, and the relationships between land use activities, lagoon openings and lagoon ecosystem health are still not fully understood. Therefore, the agencies and community are taking an incremental approach to undertake actions with known benefits now, whilst continuing to investigate the feasibility of potential actions (Strategy and Action Plan for Waituna 2015).

Little is understood about the impact of the lagoon opening on the recruitment of fish species. The presence of plenty of small fish (including giant kōkopu) in the catchment suggests that recruitment is still good. Further baseline information is required on the fish fauna in the catchment to further establish the health of populations (particularly eels as they are a taonga species), fish assemblages and habitat use in the lagoon. A full understanding of the fish fauna in the catchment will aid the Department of Conservation and the community to make decisions when considering management options (Atkinson 2008).

11.3 Biodiversity Management Area 2 - remnant lowland forest, indigenous shrubland and wetlands

11.3.1 Overview

This BMA comprises remnant lowland forest, shrubland and wetland habitats scattered throughout the catchment (Figure 7). Most of these remnants occur on private land, although sites such as the Waituna Scenic Reserve and a small remnant on the Waituna Creek (2.36 hectares) are administered by the Department of Conservation. A relatively large publicly-owned area comprising wetland and

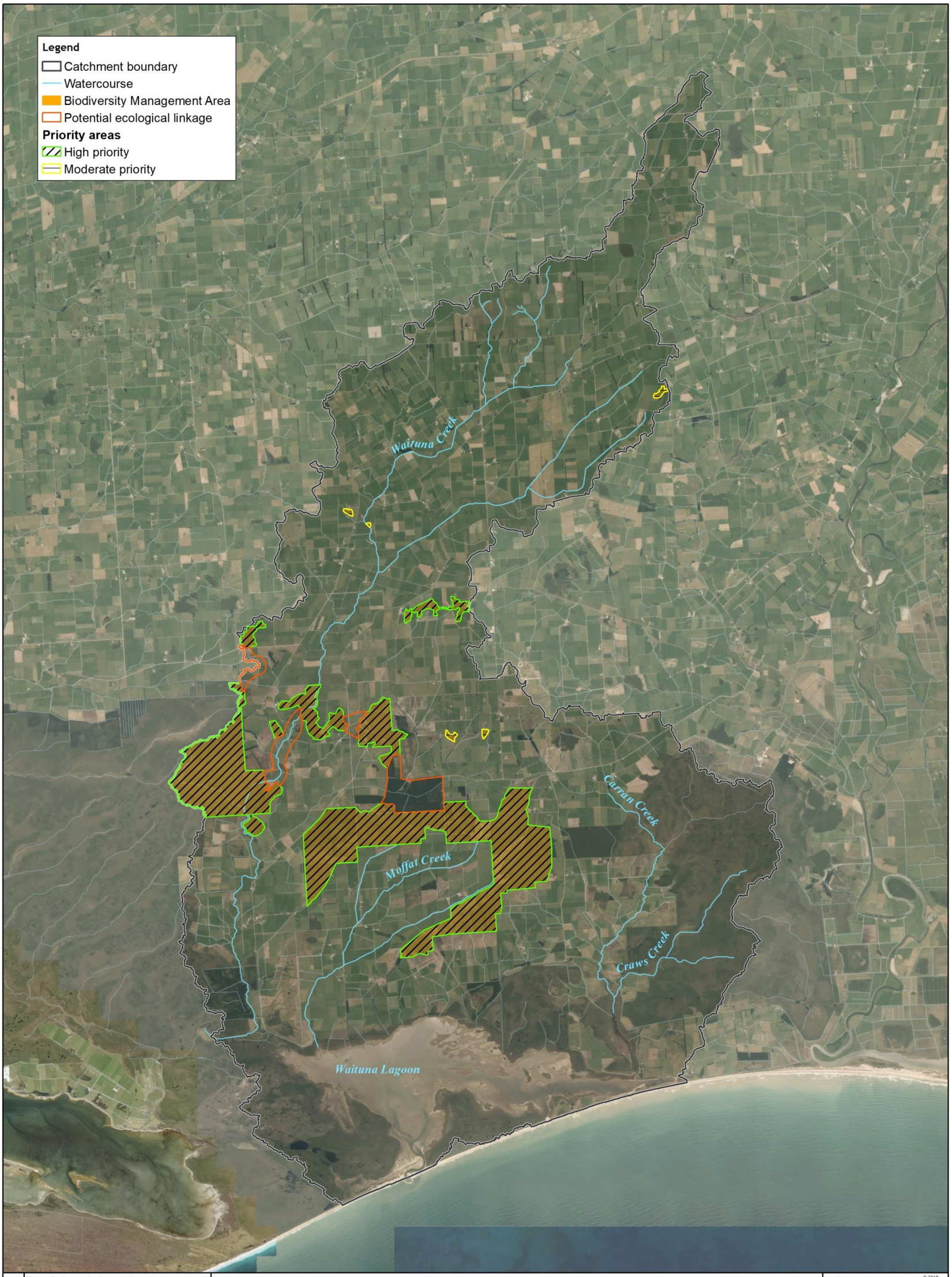

Figure 7. Biodiversity Management Area 2, Whakamana Te Waituna project area - remnant lowland forest, indigenous shrubland and wetlands

shrubland habitats is present on the western boundary of the BMA. This area, in particular, is likely to have high habitat values for indigenous lizards. Some privately owned sites within the BMA are recognised as 'High Value Areas' (HVAs). Some landowners are actively protecting the ecological values of their forest remnants through fencing and controlling pest plant and animal species.

Like much of the Southland region indigenous lowland forest has been much reduced in the Waituna catchment. At present, only a fraction of its original extent remains and is represented by small remnants scattered throughout the catchment (approximately 10% of forest that covered the Southland Plains in 1865 remains today). Small forest remnants are referred to as 'fragments' and they have the potential to provide 'habitat islands' for multiple indigenous species and individuals isolated from source areas (Gillespie & Roderick 2002). Fragments that are representative of a former type of vegetation can contribute significantly to indigenous biodiversity in highly modified landscapes (Derraik *et al*. 2001). Other remnant habitats that occur in this BMA include mānuka shrubland and wetland communities characterised by extensive bog, along with areas of fen, swamp, shallow water and ephemeral wetland classes. Wire rush is abundant in these habitat types, often occurring with flax and sedges.

11.3.2 Specific threats

- Pest animals, e.g. possums, mustelids, and rats.
- Pest plants, e.g. Chilean flame creeper and cotoneaster in dryland habitats and willow in wetland habitats. Potential for wilding conifers to invade given that some remnants are contiguous with plantation forests
- Edge effects (particularly for the smallest remnants).
- Stock access (where fencing is absent).
- Lack of enforcement could lead to further clearance and/or drainage for agricultural purposes.
- Isolation from other habitats and subsequent effects on species' population dynamics, e.g. dispersal and recruitment.
- Adverse impacts of drainage on wetland hydrology.
- Drought and fire.

11.3.3 Short-term objectives

- Undertake inventory to determine the type and regularity of management (if any) being carried out by landowners.
- Ensure all remnants are fenced to exclude livestock and feral ungulates.
- Undertake control of pest plant and animal species, including control of multiple mammal species in areas with high lizard values.

11.3.4 Long-term objectives and opportunities for enhancement

- Ensure the long-term viability of a network of highly representative lowland indigenous forest fragments through active management and legal protection in perpetuity.
- Undertake botanical surveys to determine the presence and persistence of threatened plant species.

- Enhance connectivity between existing areas through new planting, or adding to existing areas, and also to enhance connectivity between forest remnants, watercourses and wetlands (see 'Proposed ecological linkages' in Figure 7). Buffer planting with fast-growing pioneer species will also help to protect the smaller remnants from pest plant invasion and edge effects. Some areas would benefit from the removal of wilding pines; there is also an opportunity to let harvested areas of pine plantations within and/or adjacent to the BMA revert to indigenous vegetation.

11.3.5 Prioritised management targets and high level recommendations to achieve targets

Fencing, together with appropriate and regular pest control, will improve the ecological integrity of the forest remnants (i.e. by facilitating ecological processes such as fruiting, pollination, and regeneration). Some mammalian predators, such as hedgehogs and mice, are often-overlooked as predators, but can have devastating impacts on lizard populations (Newman 1994, Spitzen - van der Sluijs *et al*. 2009). Therefore, in order to be of benefit to indigenous lizards, pest control may need to cover all predatory mammal species and be undertaken in perpetuity. There is already pest control occurring within the Tiwai spit Conservation area and on parts of the Waituna Lagoon margin, so there is an opportunity to link together with these projects.

Priority 1 - Fencing of Wetland Remnants (highest priority)

Target: all wetland remnants are fenced by 2025. Wetlands are a higher priority for fencing than forest remnants given their potential to attenuate and treat farm run-off, thus improving the quality of water in downstream receiving environments.

Recommendation: use recent high-resolution aerial photography to identify and map wetlands that are not fenced. Work with landowners and QEII Open Space Trust to explore funding mechanisms to complete fencing where required.

Priority 2 - Pest Animal Control in Areas with High Lizard Values

Target: use bait stations and trapping to achieve a 5% (or less) RTC for mammalian predators in areas identified as high value habitat for indigenous lizards.

Recommendation: work with Wildlands herpetologist to determine an optimal pest management plan in high value areas. This could involve extending the existing

trapline that runs along the southern boundary of the lagoon up the western boundary of the project area.

Priority 3 - Pest Animal Control in all Remaining Sites

Target: use bait stations and trapping to achieve a 5% (or less) RTC for possums, mustelids, and rats within all remaining sites.

Recommendation: work with landowners, QEII Open Space Trust and the Department of Conservation to provide advice and funds for pest control programmes. This may require educating landowners on how to monitor pest abundance, or involve contracted pest control and monitoring.

Priority 4 - Pest Plant Control

Target: manage Chilean flame creeper from forest fragments and preventing the establishment of new infestations.

Recommendation: educate landowners on how to identify Chilean flame creeper and what techniques are available for controlling the species. Work with landowners, QEII Open Space Trust and the Department of Conservation to provide resources for weed control and to contain the spread of this species. Although no fully effective herbicide treatment is known, Weed Busters recommends using cutting and swabbing the stump with various herbicides (https://www.weedbusters.org.nz/weed-information/weed-list/chilean-flame-creeper/).

Priority 5 - Fencing of Forest Remnants

Target: all forest remnants are fenced by 2025.

Recommendation: use recent high-resolution aerial photography to identify and map forest remnants that are not fenced. Work with landowners and QEII Open Space Trust to explore funding mechanisms to complete fencing where required.

Priority 6 - Create Ecological Linkages

Target: long-term vision to return pasture to indigenous vegetation in order to link the larger remnants which are in close proximity to each other.

Recommendation: encourage landowners to consider retiring marginal, flood-prone land that is vulnerable to pugging by cattle. The ecological linkages would most likely comprise a mixture of eco-sourced forest, shrubland and wetland species such as kahikatea, tōtara, mānuka, kamahi, broadleaf/kāpuka, harakeke, and *Carex* species.

The establishment of ecological linkages would provide an opportunity to create a partnership involving landowners, the Department of Conservation, Environment Southland, Fonterra, iwi, and non-government organisations such as Forest and Bird and Federated Farmers. Grants are available to landowners for the cost of planting and establishing trees, and indigenous forest regeneration through the One Billion Trees programme. Council could also offer rates rebates to farmers who retire and restore

floodplain habitat on their land. Financial assistance for planting and fencing can be obtained through the Biodiversity Condition Fund.

Priority 5 - Lizard Monitoring

Monitoring of lizards to provide a baseline of lizard numbers prior to management and to determine whether they respond to predator control is recommended. Monitoring of green skinks (if found), cryptic skinks, and southern grass skinks could utilise a combination of two devices: Onduline retreats and pitfall traps set up together in the same location. Onduline ACOs create a thermally stable retreat for lizards that mimics the conditions of a rock crevice, which form natural retreats for lizards (Lettink & Cree 2007).

Priority 6 - Legal Protection of Privately-Owned Remnants

Target: all privately owned remnants are covenanted by 2025.

Recommendation: engage with landowners to (i) create awareness of the values of the forest fragments and to (ii) explain the enduring benefits of legal protection of the fragments.

11.3.6 Potential risks and issues

- Lack of landowner buy in/participation.
- Change in land ownership.
- Further clearance for agricultural purposes.

11.3.7 What does success look like?

All forest, shrubland and wetland remnants are legally protected, fenced, and managed for pest plants and animals. Where possible, connectivity is created/reinstated between habitat types.

11.3.8 Information gaps

There are gaps associated with the current management regime of natural areas within this BMA. In addition, there is a general lack of information on the current state/condition of the vegetation, and whether or not threatened plant and animal species are present (particularly on private land). However, some inferences can be made from information available on similar habitat types elsewhere in the catchment that are administered by the Department of Conservation.

11.4 Biodiversity Management Area 3 - Riparian margins, watercourses and drains

11.4.1 Overview

This Biodiversity Management Area encompasses all of the riparian margins along all creeks, their tributaries, and drains within the Waituna Catchment. These areas have been combined because the issues, and therefore objectives, will be similar for all riparian areas. The main waterways within the catchment are Waituna Creek, Moffat

Creek, Carran Creek, and Craws Creek, although several small un-named streams are present along the northern margin of the Waituna Lagoon. All major watercourses eventually flow into the Waituna lagoon through a mixture of agricultural land, plantation forest, wetland, forest, and shrubland habitat, which is held in a mixture of public and private ownership. All creeks and their tributaries have been modified by indigenous vegetation clearance, channel straightening and bank re-contouring, and drainage of wetland habitat, with some areas of some creeks also having remediation works to prevent erosion (e.g. bank armouring).

Drainage and land management activities to support farming over the last century have had a large and ongoing impact on all of the waterways within the catchment, all of which have altered aquatic ecosystem processes and hydrology. The mauri of the streams (awa) has also been negatively affected by the same processes. For tangata whenua, riparian zones are recognised as playing a critical role in maintaining ecological function, biodiversity, and connection between inland and coastal areas, as well as being associated with mahinga kai and other customary use activities (mahinga parenga). Riparian areas contain a range of important plant species, some of which may be used for wāhi rāranga (sources of weaving materials) or rongoā (traditional medicines). The main channel of Waituna Creek is the first priority for management. The length of waterways contained within the Waituna Creek catchment and the degree of modification of those waterways are such that they are the most significant source of pollutants for freshwater quality.

11.4.2 Waituna Creek

Waituna Creek drains a sub-catchment of 10,604 hectares and is the main tributary of the Waituna Lagoon and is integral to the health and ecology of the lagoon. The creek and catchment are highly modified with land use now dominated by dairy farming. Surveys by Holmes *et al.* (2015) and Allibone and Hudson (2015) found that instream habitat within the Waituna Creek improves in the upper reaches of the creek, but that riparian habitat in the mid-lower reaches is in poor condition and worse than the overall assessment for the wider catchment. Approximately 4.5 kilometres of riparian margin of this creek is located within protected, DOC-administered areas (Waituna Scenic Reserve, Waituna Scientific Reserve, Seaward Moss Conservation Area, and marginal strips) all of which occur in the mid to lower reaches of the creek. Several small QEII covenants are also present within the riparian zone on parts of Waituna Creek.

The mid-to-lower catchment is considered to be in greater need of management input than the upper reaches. Note that in the upper Waituna Creek catchment, nitrogen concentrations are an issue, driven by events such as winter grazing of crop paddocks. In the lower Waituna Creek catchment, phosphate concentrations from diffuse sources are more of an issue (Cain Duncan, Fonterra, pers. comms. 2018). Despite the level of degradation, there are historical records of up to 18 indigenous fish species from the Waituna Lagoon catchment, including one ‘Threatened’ species and four ‘At Risk’ species (Riddell 1988; Chesterfield 2005; Atkinson 2008) (see Table 7, Section 8.4 for freshwater species recorded from this waterway).

11.4.3 Carran Creek

Carran Creek drains a sub-catchment of 2,871 hectares and is a slow-flowing single channel watercourse that empties into the easternmost extent of the Waituna Lagoon. Scientific monitoring of Carran Creek shows that it is in 'the worst 25% for like sites' for clarity, nitrogen, and phosphorous. The creek is in 'the worst 50% for like sites' for *E. coli* (Land Air Water Aotearoa 2018a). The upper reaches of the creek mostly flow through agricultural land with some small areas of remnant wetland, and small areas of plantation forest; these areas have often been channelised and generally lack riparian buffering. Large sections of the mid to lower reaches of Carran Creek flow through the DOC-administered areas (Toetoes Conservation Area, Toetoes Scenic Reserve, Waghorn Scenic Reserve, Waituna Wetlands Scientific Reserve) and, while some channelisation is present, the creek is significantly less modified than the upper reaches. In spite of the poor water quality rating of the creek, Carran Creek supports at least six indigenous fish species (see Table 7, Section 8.4), two of which are classified as 'At Risk' by Dunn *et al.* (2018).

11.4.4 Moffat Creek

Moffat Creek drains a sub-catchment of 1,733 hectares and is a slow flowing watercourse with a gravel bed that drains into the Waituna Lagoon approximately three kilometres to the east of the Waituna Creek. With the exception of its headwaters, Moffat Creek is largely devoid of woody riparian vegetation and, like Waituna Creek, it has been extensively channelised to improve drainage of surrounding farmland; the creek is also impacted by sediment deposition and extensive macrophyte growth. With the exception of the mouth of Moffat Creek, all riparian areas within the Moffat Creek catchment are privately owned and unprotected.

Scientific monitoring of Moffat Creek shows that it is in 'the worst 25% for like sites' for *E. coli*, clarity, nitrogen, phosphorous, and Macroinvertebrate Community Index (MCI) (Land Air Water Aotearoa 2018b). Despite these poor results, Moffat Creek supports at least five indigenous fish species, two of which are classified as 'At Risk' by Dunn *et al.* (2018) (see Table 7, Section 8.4).

11.4.5 Craws Creek

Craws Creek drains a sub-catchment of 788 hectares and is also a slow flowing watercourse that discharges into the lower reaches of Carran Creek. The headwaters and mid-reaches of Craws Creek flow through Waghorn Scenic Reserve, and are thus relatively well-buffered by indigenous shrubland and wetland. Pest plant control and planting at a restoration site adjacent to the creek has been undertaken by the Department of Conservation.

11.4.6 Specific threats

As described above, all of the waterways within the catchment have been affected by the same processes associated agricultural activities. Specific threats to indigenous biodiversity and healthy stream ecosystems include:

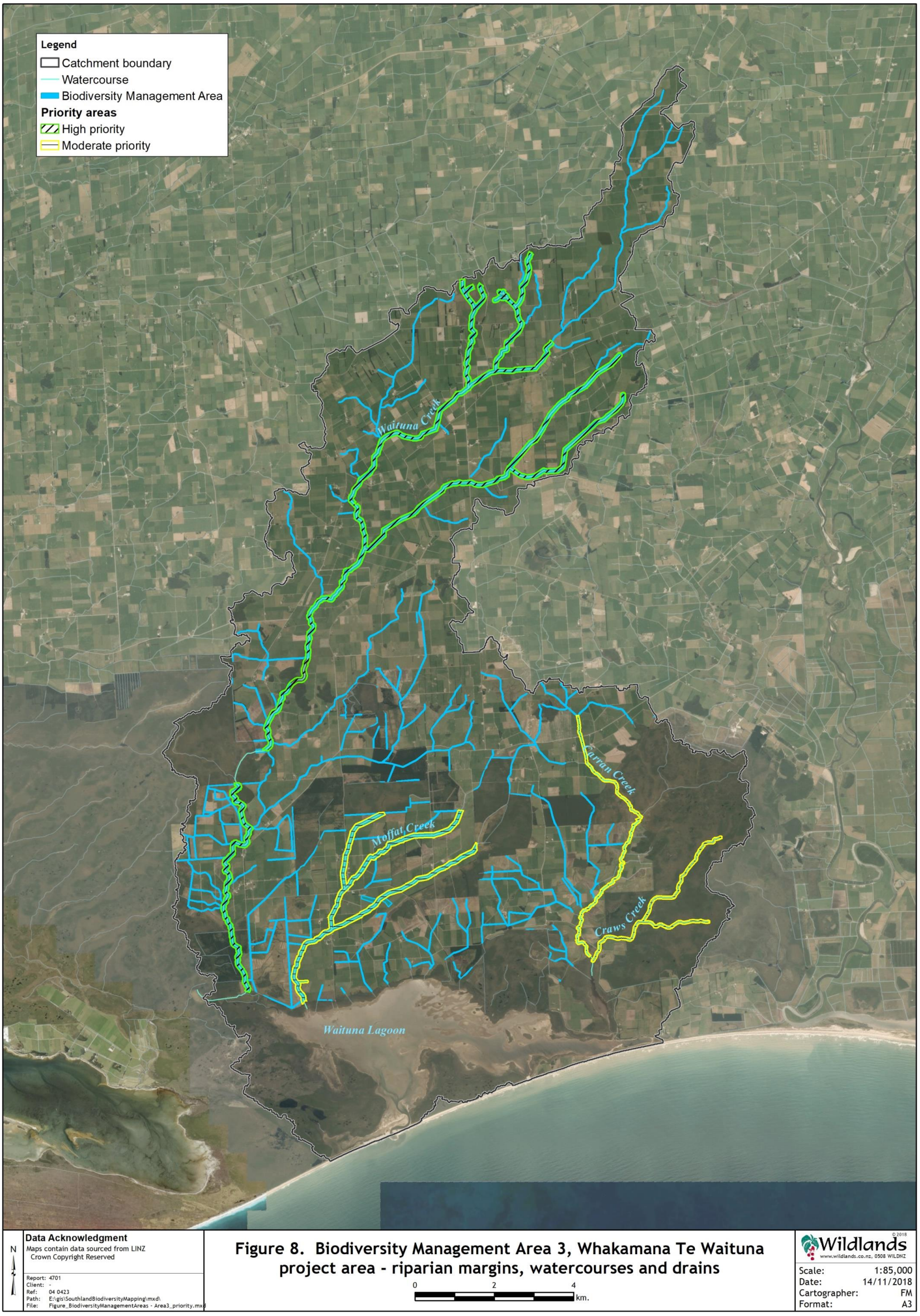

Figure 8. Biodiversity Management Area 3, Whakamana Te Waituna project area - riparian margins, watercourses and drains

Hydrological Modifications

The hydrology of the streams has been altered through channel straightening, channel deepening, bank re-shaping, bank armouring, removal of instream features which support instream fauna habitat, aquatic plant removal, and sediment removal.

Lack of Stable in-Stream Habitat

To enable fish and invertebrates to have places to feed, rest, spawn, and evade predators, they need structurally complex habitats (McDowall 1990; McMahon *et al*. 1996; Jellyman *et al*. 2016). This includes varied water depths and velocities, such as those provided by pools, runs and riffles; varied substrate particle sizes, such as sand, gravel, cobbles, rocks, and branches/logs; and instream vegetation, which provides structure, food for instream fauna, and oxygenates the water (McDowall 1990; Jellyman *et al*. 2016). In-stream vegetation can however retard water flow which can increase flooding incidence and extent, so is often completely removed from a waterway.

Barriers to Fish Migration

Unimpeded passage of fish within waterways is important for their regular activities, such as feeding, predator evasion, resting, and spawning (McDowall 1990; Silva *et al*. 2018). Fish passage is required for both migratory and non-migratory species. Fish migration, both upstream and downstream, takes place for particular species at specific times of the year, when fish need to move between marine and freshwater environments to compete their life cycle (McDowall 1990 and 2000; Richardson *et al*. 2001). Many of the fish present in the Waituna Lagoon catchment are migratory, e.g. giant kōkopu, eel/tuna, banded kōkopu, inaka/inanga.

Fish passage and migration can be impeded by several factors such as physical structures in the waterway (e.g. perched culverts, long smooth-bottomed culverts that create velocity issues for fish migrating upstream), reduced water levels due to natural seasonality and/or water abstraction (surface and/or ground water), vehicles fording the waterway, continued disturbance of the wetted channel by heavy machinery, and inputs of sediments and chemical contaminants to the waterway (McDowall 1990; Rowe and Dean 1998; Rowe *et al*. 2000; Richardson *et al*. 2001; Rowe *et al*. 2009; Liermann *et al*. 2012; Silva *et al*. 2018).

Erosion and Slumping of Stream Banks

Erosion and slumping of stream banks has the potential to reduce instream habitat for freshwater fauna, results in direct sediment and nutrient inputs into the stream, may smother macrophyte habitat, and may result in tensions between biodiversity goals and landowner goals to not lose any land.

Excess Nutrient and Sediment Loads and Subsequent Algal Growth

Sediment loading of the water within the waterways and high direct and indirect nutrient input has the potential to result in excessive algal or macrophyte growth which may reduce habitat for indigenous freshwater fauna. Reduction of plant growth

will then require less mechanical disturbance of the waterways and/or herbicide use. Such mechanical disturbance can directly and indirectly kill aquatic fauna and disturb fish migration.

Lack of Fencing or Insufficient Fencing

Poor fences or lack of fences around waterways will often result in domestic stock having direct access to waterways. Fencing to exclude stock from waterways and water bodies is important to prevent mechanical damage caused by stock walking on banks and in the water, and to prevent the direct application of nutrients whilst stock are in the water. Fencing will also protect riparian plants from grazing, enabling them to grow better and provide more effective habitat for indigenous species and ecological services such as nutrient uptake.

Lack of Riparian Vegetation and Buffering

Waterways can be adversely affected by surrounding land uses and become degraded. An effective way to prevent such degradation is to improve the riparian zone immediately adjacent to the waterways. This zone will then buffer land use impacts by removing sediments and nutrients, helping to support aquatic functions, protect aquatic life, stabilise banks, and sustain healthy indigenous riparian vegetation for invertebrates and other wildlife. Research shows that a range of buffer widths are useful for these functions, from 5 metres to greater than 30 metres (Hawes and Smith 2005; Parkyn 2004; Parkyn *et al.* 2000; Wildland Consultants 2000). A buffer width ranging from 10 to 20 metres has been assessed as the minimum necessary to enable vegetation within the zone to be ecologically sustainable and to achieve many aquatic functions within the waterway (Parkyn 2004).

Mechanical Removal of Macrophytes

Mechanical removal of macrophytes from the bed of waterways can negatively affect instream habitat values by compacting the substrate through use of heavy machinery in the stream bed and disturbing structurally complex habitats and instream structures which provide refuge or habitat for aquatic fauna.

Pest Plant and Pest Fish Species

Pest plant species can rapidly invade and out-compete indigenous species in some situations thereby reducing indigenous biodiversity. Pest fish species in the Waituna catchment are currently limited to brown trout. Trout species are known predators of indigenous fish such as galaxids and bullies. Gollum galaxid (*Galaxias gollumoides*) has been recorded from Carran Creek and is therefore vulnerable to predation by brown trout.

11.4.7 Potential opportunities for enhancement/restoration

Two recent reports by Holmes *et al.* (2015) and Allibone and Hudson (2015) identify three broad opportunities for restoring and enhancing ecological values within the Waituna Creek catchment. Given the similarities between the threats facing all

watercourses within the catchment, these three broad opportunities can be scaled up to include riparian zones and instream habitat for all waterways within the catchment:

- **Instream habitat restoration** which includes:

    - adding structures such as logs and rocks or trialling artificial structures with similar function
    - creating greater hydrological heterogeneity
    - encourage/allow streams to develop greater natural variability in form, width, depth, velocity
    - improving stream shading and riparian litter inputs through planting
    - preserving/creating undercut banks to improve in-stream habitat
    - reconnect meander channels and 'backwaters'
    - reducing fine sediment load
    - removing barriers to indigenous fish passage

- **Riparian habitat restoration** which includes:

    - fencing and excluding stock
    - creating and improving habitat connectivity
    - planting suitable stream edge vegetation for giant kōkopu spawning
    - riparian planting for bank stability, biodiversity enhancement, and vegetation inputs to the stream
    - indigenous species used for riparian planting should also have regard for plants which are important for cultural and medicinal use by the tangata whenua

- **Water quality improvement** which includes:

    - diverting sediment deposition away from low flow channel
    - reducing fine sediment and nutrient input
    - trialling tile drains and channel modifications to encourage/support water quality improvement and manage sediment deposition
    - using riparian buffering and planting around areas of overland flow with particular emphasis

All of the enhancement and restoration options listed above will also improve the mauri of the waterways within the catchment. In addition to the broad rehabilitation and enhancement options that have been identified, it would be useful to identify projects at specific locations on each watercourse and provide a targeted restoration plan for those priority areas. A Waituna Creek workshop was held in 2018 with relevant experts, where the creek length was physically walked, and project sites identified and discussed. The purpose of this was to develop options to provide to the Whakamana te Waituna trustees so that decisions can be made on work to be carried out over the course of the partnership (Whakamana te Waituna 2018). It would be valuable, though not essential, to undertake a similar process for the other main waterways within the catchment. All of these opportunities will require extensive consultation with landowners and relevant agencies.

11.4.8 Short-term objectives

- Maintain the function of the existing riparian zone including riparian vegetation of all streams and their tributaries within the catchment.
- Ensure no worsening of riparian state and water quality within the catchment.
- Protect existing habitat for indigenous fish species.
- Identify priority areas for ecological management within along each stream catchment.
- Identify priority areas for cultural use within the BMA.

11.4.9 Long-term objectives

- Riparian zones throughout the catchment will be enhanced where necessary to improve function and connectivity with instream habitat values.
- Water quality parameters will improve significantly.
- No barriers to fish passage will be present within the catchment.
- Natural stream function and shape will be enhanced throughout the catchment.
- Connectivity to backwaters, meanders, and isolated wetland areas will be restored.
- Restore and enhance instream habitat for indigenous freshwater species.
- Reduce instream sediment load reaching the Waituna Lagoon.
- Restore the potential for cultural harvest and food.
- Restore the mauri of the waterways within the catchment.

11.4.10 Prioritised management targets and high level recommendations to achieve targets

<u>Priority 1 - Fencing to Exclude Domestic Stock from Riparian Margins</u>

The entire length of all natural streams and tributaries with permanent to intermittent flows within the catchment are fenced to exclude all domestic stock. Fences should be placed to include a fifteen metre buffer strip on main stream channels and a minimum of five metres on tributaries (see below). Ephemeral stream courses may be completed as a secondary priority as time and resources allow.

Recommendations:

- Work with landowners, the Department of Conservation, Environment Southland, and Fonterra, to explore funding mechanisms to complete fencing where required.

- Main stream channels as high priority; tributaries as moderate priority.

- Break down the length of each side of the stream into manageable chunks where fencing and planting can be undertaken concurrently. This will reduce the likelihood of pest plant incursion and subsequent dominance should periods of low funding/resources occur prior to all works being completed.

- Enlist community groups and/or schools to help achieve planting and maintenance targets. Consider an ‘adopt a stream length’ strategy.

Priority 2 - Restoration Planting of Buffer Strips Along all Natural Waterways

Once fenced to exclude domestic stock, restoration planting with appropriate indigenous species should be undertaken within a fifteen metre buffer zone on each side of each main stream channel and a minimum five metre buffer on each side of the tributaries. Prioritise waterways with permanent and intermittent flows. Ephemeral watercourses may be completed as a secondary priority as time and resources allow.

Recommendations:

- Work with landowners, the Department of Conservation, Environment Southland, and Fonterra, to explore funding mechanisms to assist with this planting where required.
- Main stream channels as high priority; tributaries as moderate priority.
- Break down the length of each side of the stream into manageable chunks where fencing and planting can be undertaken concurrently. This will reduce the likelihood of pest plant incursion and dominance should periods of low funding/resources occur prior to all works being completed.
- Enlist community groups and/or schools to help achieve planting and maintenance targets. Consider an 'adopt a stream length' strategy.
- Restoration plantings should be taller and denser on the northern aspects of waterways to help reduce in-stream vegetation growth, thereby reducing the need for in-stream maintenance. All plants should be eco-sourced from the Waituna Ecological District. Appropriate plant species include kahikatea, tōtara, mānuka, kamahi, broadleaf/kāpuka, harakeke, and *Carex* species (e.g. *Carex virgata*, *C. secta*, and C.

Priority 3 - Pest Plant and Pest Animal Control

Install a terrestrial pest animal trapping and monitoring network throughout natural habitats within the catchment. Implement or expand existing pest plant (terrestrial and aquatic species) surveillance and control programme to include the riparian zones of all waterways within the catchment once fenced to exclude all domestic stock.

Recommendations:

- Engage with landowners, the Department of Conservation, Environment Southland, local scientists, and tertiary institutions.
- Undertake a survey to determine the best places for concentrating pest animal efforts.
- Install tracking tunnels and other pest animal survey methods (e.g. chew cards) in target areas for pest animal management.
- Install pest animal trapping and bait stations in areas identified by tracking tunnels as containing the highest pest animal densities. Note that pest animals such as

mustelids and feral cats will navigate along watercourses to move across the landscape, therefore it would be prudent to install traps (e.g. DOC200 and Conibear traps) at regular intervals along major watercourses.

- Aim for complete eradication of feral ungulates, given that they have not yet established in the area. Prioritise protection of areas that support known populations of threatened plant species.
- Aim to achieve RTC indices for possums of less than 5%.
- Aim to achieve RTC indices for rodents of less than 5%, although biodiversity gains will still be realised at less than 10%.

Priority 4 - Restore Ecological Function of Streams

Modified waterways do not adequately retard sediment deposition, lack habitat for freshwater fauna, and provide ideal sites for macrophyte growth. Refer to the Waituna Creek Transformation report (Pattle Delamore Partners Limited 2016) for details.

Recommendations:

- Engage with landowners, the Department of Conservation, Environment Southland, local scientists, and tertiary institutions.
- Focus on poor quality habitat identified by Holmes et al. (2015) and create instream features that support the target species, e.g. deep pools, undercut banks.
- Where streams have to remain channelised, install artificial habitat structures detailed in Allibone & Hudson (2015) to provide permanent habitat.
- Identify modified stream courses where natural stream character can be allowed to return via removal of bank armouring or other engineered works.
- Ensure riparian buffer planting includes vegetation which will provide allocthonous inputs to, and shading of, the stream channel.
- Ensure riparian buffer planting includes vegetation which will provide suitable habitat for giant kōkopu to spawn.
- Trial selective vegetation removal where macrophytes are an issue for landowners/managers rather than complete removal.

Priority 5 - Improving Instream Habitat Management

The following recommendations are described in the Waituna Creek Transformation report (Pattle Delamore Partners Limited 2016):

- Where possible, reshape banks and base of waterways to provide deep and shallow areas.

- Add logs and root wads to increase large stable habitat, noting that these objects will need to be either dug into the stream bank or pinned in place with steel cables.
- Improve variety in substrate by introducing varied sizes of aggregate.
- Allow a minimal amount of in-stream vegetation to remain. This could be uniformly along the waterway, or in selected sections.

Priority 5 - Improving Fish Passage Throughout Watercourses

- Investigate all natural streams and drains with permanent to intermittent flows as a priority within the catchment to assess fish passage barriers, noting the drains should only be considered if they have connectivity to natural watercourses If blockages to fish passage are found, such as perched culverts or ford drop-offs, these should be either replaced or retrofitted to allow fish to easily navigate them. Ephemeral stream courses and drains could be investigated as a secondary priority if time and resources allow.
- Fish passage solutions (e.g. fish ladders or ropes, rock ramps, culvert floor modification) could be trialed.

Priority 6 - Restore Hydrological Function of Streams and Wetlands

Restoration of natural hydrological connectivity between streams, meander channels, 'backwaters' and wetland areas will significantly improve water quality within the streams and therefore the lagoon and provide additional habitat for indigenous freshwater fauna.

Recommendations:

- Engage with landowners, the Department of Conservation, Environment Southland, local scientists, and tertiary institutions.
- Undertake survey to investigate opportunities for reconnecting meander channels and 'backwaters' and identify priority areas for management.
- Create channel features to promote sediment deposition out of the low flow channel for removal at a later date.

Priority 7 - Reduce the Impacts of Drains on Catchment Hydrology

Fence and plant buffer areas along drains where practicable, infill or modify hydrological function of drains where practicable to restore a more natural hydrology in areas where drains are present.

Recommendations:

- Work with landowners to explore alternative management regimes for areas where regular drain management is still necessary.
- Work with landowners to explore places where drains could be infilled.

- Work with landowners to identify areas where buffer zones could be fenced and planted along some drains.
- Work with landowners, the Department of Conservation, Environment Southland, Dairy NZ, Fonterra,, to explore funding mechanisms to complete fencing where required.
- Explore options for deep drains/main lateral drains and drains through wetlands as a first priority. Smaller, shallow drains as a secondary priority.
- Promote natural flushing and deposition of sediments to reduce the need for intervention.
- Create shade to avoid excessive macrophyte growth.
- Design sediment deposition areas in channel which can be managed without disturbing low flow channel habitats.
- Agree on access points for channel maintenance and plant around these to avoid disturbance of riparian zones.
- Establish monitoring for soil moisture levels on farms to inform effects of drainage activities and lagoon levels

Priority 8 – Secure Populations of Gollum Galaxid in Carran Creek

Recommendations:

- Undertake repeat surveys of locations where Gollum galaxids have previously been recorded from Carran Creek.
- If populations are discovered, consider installing trout barriers to prevent the upstream migration of brown trout. Trout barriers will also benefit a range of other indigenous aquatic fauna such as bullies, giant kōkopu, and koura.

11.4.11 What does success look like?

- The riparian zones of all creeks are fully fenced and planted with appropriate indigenous plant species.
- All barriers to fish passage are resolved.
- Connectivity with floodplain and wetlands has been reinstated.
- Environmental indicators (e.g. E. coli, total nitrogen, and MCI) show an improving trend over time both within the creeks and within the Waituna Lagoon.
- Tuna/longfin eels and other indigenous fish species have increased in abundance and are utilising in-stream structures such as log vanes, together with aquatic macroinvertebrates.

- Abundant and healthy indigenous fish, plant, invertebrate, reptile and bird populations; protection of wetlands in the catchment as refuges of biodiversity and for the ecosystem services they provide; and lagoon, stream, and wetland ecosystems thrive and support indigenous biodiversity.
- Reduced competition from pest plants has allowed indigenous species to establish and flourish.
- Abundant and healthy mahinga kai including: strong kōkopu, pātiki (flounder), tuna, kanakana (lamprey), kōura (freshwater crayfish), inaka (whitebait), and potentially gollum galaxid populations.

11.4.12 Potential risks and issues

- Lack of community/landowner buy in.
- Lack of funds for planting and fencing, and continued maintenance.
- Further vegetation clearance for agricultural purposes.
- Financial implications for landowner retiring productive land.
- Conflicting priorities and objectives between organisations.
- Availability of workforce to complete and maintain riparian planting.
- Further agricultural intensification and drainage in the catchment.
- Current and future projects are largely focused on the mid to lower reaches of the Waituna Creek. Full benefits of restoration will not be realised unless the entire catchment is also considered.

11.4.13 Information gaps

There is little information on how much nutrient load Carran Creek contributes to Waituna Lagoon. It is not known what proportion of the upper reaches of Waituna Creek is already fenced to exclude stock.

11.5 Biodiversity Management Area 4 - Pasture and indigenous fragments on private agricultural land

11.5.1 Overview

This BMA comprises the balance of land outside of the other three BMAs, which is mostly pasture with patches of pine plantation and very small fragments of indigenous forest and wetland habitats not identified as HVAs (Figure 9). It also includes retired pasture adjacent to Craws Creek, which forms a small part of Waghorn Reserve. A buffer of pasture (*c.*100-150 metres wide) on the landward side of the lagoon is proposed for restoration to better protect the ecological integrity of Waituna Lagoon and associated wetland habitats (Figure 9). Pine plantations and indigenous habitats in this BMA have been identified using the Land Cover Database (v.4.1), and it is

possible that some sites have since been cleared or drained. A large proportion of this BMA supports dairy farming and is thus integral to the health of the Waituna catchment. With the transition towards farming under environmental limits, the potential value of maintaining and enhancing remnant wetland areas on farms needs to be reassessed. In many cases these relatively small natural wetlands (such as those that occur in BMA 4) can provide important attenuation assets, significantly reducing export of contaminants from the catchment (Tanner *et al.* 2015).

11.5.2 Specific threats

- Nutrients leaching from pasture into drains and streams.
- Pest animals and plants.
- Edge effects (particularly for the smallest remnants).
- Stock access (where fencing is absent).
- Soil compaction.
- Lack of legal protection could lead to further clearance and/or drainage for agricultural purposes.
- Isolation from other habitats and subsequent effects on species' population dynamics, e.g. dispersal and recruitment.

11.5.3 Prioritised management targets and high level recommendations to achieve targets

Fencing, together with appropriate and regular pest control, will improve the ecological integrity of indigenous remnants (i.e. by facilitating ecological processes such as fruiting, pollination, and regeneration). Restoration of pasture (floodplain) buffering the riparian margins of major watercourses would create ecological linkages and significantly reduce nutrient input into the catchment. Specific targets are listed below.

<u>Priority 1 - Fencing Wetlands</u>

Target: fence all remaining wetlands (indigenous and exotic) by 2021.

Recommendations: use recent high resolution aerial photography to identify and map all wetlands not already captured, and determine whether or not they are fenced. Consult with landowners to underscore the importance of wetlands (even small degraded systems) for treating nutrients, noting that a recent study by Tanner *et al.* (2015) found that wetlands on private land comprising 2-3% of the Waituna catchment are predicted to be able to remove 30-40% of nitrate-N in run-off.

Work with landowners and QEII Open Space Trust to explore funding mechanisms to complete fencing where required.

<u>Priority 2 - Restoring Buffer Adjacent to Waituna Lagoon</u>

Target: long-term vision to restore indigenous habitat (currently in pasture and degraded wetlands) up to 150 metres along the landward margin of Waituna Lagoon. It would be difficult to put a timeframe on this, given that most of the land is privately

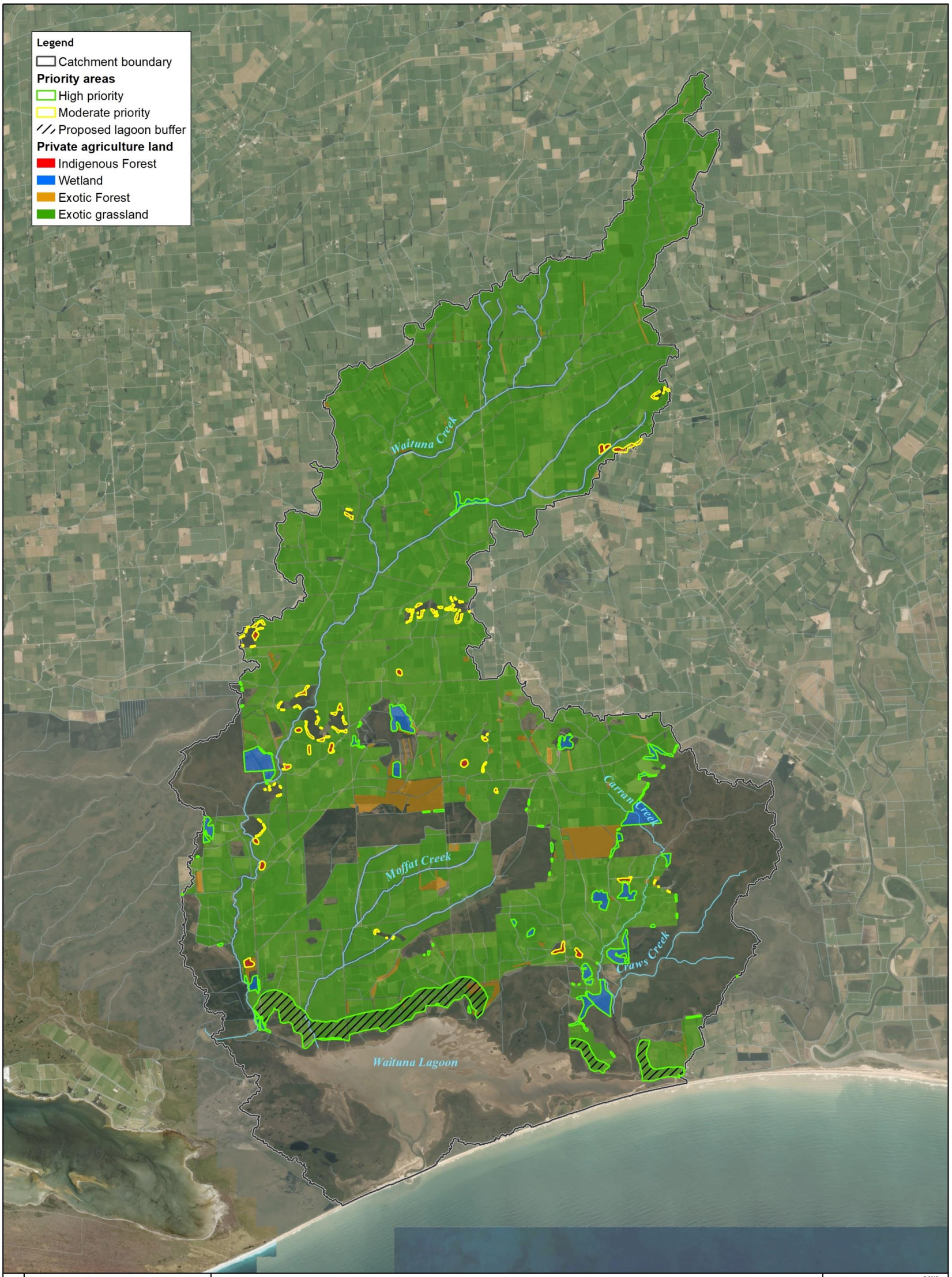

Figure 9. Biodiversity Management Area 4, Whakamana Te Waituna project area - pasture and indigenous fragments on private agricultural land

owned. In the short-term, pasture owned by the Department of Conservation (near Craws Creek) should be planted with appropriate indigenous plants, which in turn may encourage nearby landowners to participate (noting that some revegetation has already taken place in this area).

Recommendation: most farmers in the lower catchment would be aware of the adverse impacts that dairy farming has had on Waituna Lagoon. The idea of working with landowners to scope and investigate potential locations and benefits arising from retirement of land around the lagoon has previously been raised by the Waituna Working Group.

Landowners should be encouraged to consider retiring marginal, flood-prone land that is vulnerable to pugging by cattle. Planting would most likely include a mixture of forest, shrubland, and wetland species, the proportion of which would largely be influenced by soil moisture. The aim would be to create floristically diverse assemblages of podocarp and swamp forest species grading into manuka-wire rush dominant shrubland and wetter areas dominated by sedgeland.

Large-scale floodplain restoration would involve guidance from existing Waituna trustees/partners (Department of Conservation, Environment Southland, Southland District Council, Te Rununga o Awarua, and Te Rununga o Ngai Tahu), who could engage with landowners, non-government organisations such as Forest and Bird and Federated Farmers, and the Billion Trees government initiative. Planting at this scale would also help future-proof the lagoon against the impacts of weed encroachment and climate change, e.g. buffering against drought and severe storms. Grants are available to landowners for the cost of planting and establishing trees, and indigenous forest regeneration through the One Billion Trees programme. Council could also offer rates rebates to farmers who retire and restore floodplain habitat on their land. Financial assistance for planting and fencing can be obtained through the Biodiversity Condition Fund. Alternatively, Environment Southland and the Department of Conservation could investigate the potential of land swaps or land purchases.

Priority 3 – Control of Pest Animal Species

Target: use bait stations and trapping to achieve a 5% (or less) RTC for possums, mustelids, and rats within indigenous fragments, although it is acknowledged that reinvasion will be an issue unless a catchment-wide programme is adopted.

Recommendation: work with landowners, QEII Open Space Trust and the Department of Conservation to provide advice and funds for pest control programmes. This may require educating landowners on how to monitor pest abundance, or involve contracted pest control and monitoring. In addition, landowners should be made aware of the funding and technical assistance available from Environment Southland.

Priority 4 – Control of Pest Plants

Target: improve ecological integrity and hydrological function of wetland and ring drains through the removal of pest plant species.

Recommendation: work with landowners, QEII Open Space Trust and the Department of Conservation to provide advice and funds for controlling pest plant species. Some aquatic pest plant species may require mechanical removal.

Priority 5 - Legal Protection of Privately-Owned Sites

Target: all privately owned indigenous fragments are legally protected by 2025.

Recommendation: engage with landowners to (i) create awareness of the values of indigenous forest and wetland fragments and to (ii) explain the enduring benefits of legal protection of the fragments.

11.5.4 Potential risks and issues

- Lack of landowner buy in/participation.
- Change in land ownership.
- Further clearance for agricultural purposes.
- Further intensification of dairying in the catchment.

11.5.5 What does success look like?

All remaining indigenous forest, shrubland and wetland remnants are legally protected, fenced, and managed for pest plants and animals. All exotic wetlands are fenced and buffered by indigenous plantings, and are thus able to act as nutrient filters.

12. POTENTIAL FOR CROSS-BMA IMPACTS AND MITIGATION

12.1 Overview

Threats such as pest species and stock have the potential to adversely affect the ecological integrity of all BMAs. A catchment-wide focus should therefore be adopted when implementing management actions rather than focusing on BMAs in isolation. There are opportunities to combine restoration efforts, such as fencing and reinstating natural hydrological regimes, where BMAs intersect In addition, creating linkages in between areas with comparatively high indigenous biodiversity and those areas that are predominantly pastoral, will significantly enhance the ability of fauna to move through the 'patchwork' of natural areas. These connections will thereby enhance biodiversity goals within lower catchment BMAs and upper catchment BMAs.

Indigenous aquatic fauna are central to the biodiversity of the Waituna catchment, and the opportunities for restoring habitat for fish and invertebrates should also be viewed in a cross-BMA context. Key management recommendations for instream habitat, riparian margins, and fish passage are applicable throughout the catchment, in particular BMAs 3 and 4.

The following sections outline broad opportunities for cross-BMA efficiencies in the Waituna catchment.

12.2 Pest animal control

Greater efficiencies will be gained by focusing pest animal control on the lower Waituna catchment, which contains far more indigenous habitats than the northern part of the catchment. There is an opportunity to extend existing trap lines and bait lines around BMA 1 to incorporate privately owned remnants in BMAs 2 and 4, and also the Waghorn Scenic Reserve in the eastern part of BMA 1. The Predator Free Waituna project may be able to achieve this, as traps have recently been sent to Environment Southland and should be installed in summer 2018-2019 (Ali Meade, pers. comm. 23 November 2018).

12.3 Pest plant control

Similarly, pest plant control should be concentrated in the southern half of the catchment, with a focus on wetland, shrubland and forest habitats in BMAs 2 and 4. Key species to control include grey willow, Chilean flame creeper, gorse, and Spanish heath.

Pest plant control in any of the BMAs will have flow-on effects to the remaining areas of nearby BMAs by reducing seed sources. Conversely, not undertaking pest plant control within a lower priority BMA may result in reinvasion of pest plant species to a higher priority BMA. Consequently, the aim should be to eliminate larger source populations of pest plant species. It is also noted that pine plantations are located in the southern half of the catchment, all of which have the potential to act as sources for wilding pine infestations.

12.4 Ecological linkages

Fencing and planting riparian corridors would create important ecological linkages between terrestrial, aquatic and wetland habitats in BMAs 2, 3, and 4, whilst also significantly improving water quality. There is also the opportunity to connect currently isolated forest fragments in BMAs 2 and 4, and create linkages with the proposed landward buffer along Waituna Lagoon in BMA 4. All indigenous plant species used to creating linkages should be eco-sourced from the Waituna Ecological District.

16. PRIORITISATION ACROSS BIODIVERSITY MANAGEMENT AREAS

16.1 Tier 1 - High priority

- Waituna Lagoon - BMA 1. **Rationale:** Waituna Lagoon is one of the best remaining examples of a natural coastal lagoon remaining in New Zealand. Protecting the ecological viability of the lagoon is of upmost importance given its internationally significant biodiversity, status as a Ramsar site, and importance to iwi. It faces a multitude of threats including increases in nutrient loading and subsequent algal blooms, sea level rise, increased storm intensity and frequency, and risks associated with the lagoon opening regime. A catchment-wide effort is

required amongst all key stakeholders to prevent a regime shift in the lagoon from a macrophyte-dominated system to an algal-dominated system. In addition, it is a high priority to undertake pest animal control around the lagoon given the exceptional fauna values present.

- Waituna Creek - BMA 3. **Rationale:** Waituna Creek is the largest watercourse in the catchment and transports the high loads of nutrients in the lagoon. The health of the lagoon is dependent on the health of the creek. A number of opportunities have been identified to help restore the Mauri of Waituna Creek, particularly in the mid to lower reaches. Riparian buffers are critical to the health of watercourses in the catchment. Priority should be given to fencing and eventually planting a 10-15 metre buffer on each side of the main stem of the creek. Other important projects within this BMA include reconnecting the creek riparian with nearby protected areas (nearby QEII covenants and Waituna Creek Scenic Reserve) and unprotected areas (gravel pit reconnection and Fogerty Forest pond and meander loop) as well as the eventual reconnection of the creek with flood plain habitat (Whakamana te Waituna 2018).

- Wetlands in BMA 2 and BMA 4. **Rationale:** BMA 2 comprises intact wetland vegetation that is administered by the Department of Conservation. The BMA is considered to have excellent potential to support indigenous lizard species, and it also provides a corridor linking the Waituna Scenic Reserve and the Seaward Moss Conservation Area. All wetland habitats, including small exotic systems, have the potential to significantly reduce the amount of nutrients entering watercourses and the lagoon. It is critical that their value and contribution is recognised by all stakeholders.

- Larger, less isolated lowland forest remnants - BMAs 2 and 4. **Rationale:** These fragments are highly representative of a once widespread lowland vegetation type, although they are small and vulnerable to ongoing pest plant and animal invasion. All of these sites are privately owned and several are already under active management by landowners in conjunction with the Open Space Trust. Management actions such as fencing and pest plant and animal control are relatively straightforward and cost-effective, and would deliver positive ecological outcomes in the short to medium-term. The location and size of these remnants provide better potential for creating linkages with forest and wetland habitats.

- Craws Creek - BMA 3. **Rationale:** Craws Creek has the smallest catchment and is least affected by agricultural activities compared with the other three major watercourses. It contains some of the better quality aquatic habitat and there is an excellent opportunity to continue planting into adjacent pasture and thus improve connectivity with Waghorn Reserve and wetlands. This is likely to occur with funding from the Department of Conservation and the Billion Trees initiative.

16.2 Priority actions to be completed by 2024

Central to the health of the Waituna catchment are water quality and hydrology. Priority should therefore be given to projects that aim to protect and enhance watercourses, restore connectivity with floodplains and wetlands, and reduce nutrient and sediment loads. Taking into account the limited resources and funds available, the

following priority actions are recommended for implementation within the next five years:

- Agreement between stakeholders on lagoon opening regime.
- Create a fenced buffer (minimum of 150 metres wide) along the landward side of the lagoon.
- Fence and plant a riparian buffer along the main stem of Waituna Creek.
- Fence all wetlands in the catchment where stock currently have access. Doing so has the potential to significantly improve the quality of water flowing into downstream receiving environments.
- Undertake riparian and wetland planting adjacent to Craws Creek (subject to availability of funding).
- In addition to the above-mentioned measures, key stakeholders agree that completing a trapping and bait station network around as much of the lagoon as possible is a high priority (incorporating the proposed buffer).

16.3 Tier 2 - Moderate priority

The following BMAs are considered to be of moderate priority for protection and enhancement due to their relatively small size and/or lack of ecological connectivity. In saying that, important gains in biodiversity and water quality within the catchment would be realised if actions such as fencing, planting, and pest plant and animal control could be implemented as and when funds become available.

- Carran Creek - BMAs 3. **Rationale:** Carran Creek contributes sediment and nutrients from agricultural land to Waituna Lagoon, thereby directly affecting the health of the lagoon and its plant communities. Recent environmental monitoring indicates that Carran Creek is currently in a poor ecological state. The wetlands to the east of the creek provide some buffering against the impacts of farming and are likely to support a number of indigenous fauna species.
- Moffat Creek - BMA 3. **Rationale:** Moffat Creek contributes sediment and nutrients from agricultural land to Waituna Lagoon, thereby directly affecting the health of the lagoon and its plant communities. Recent environmental monitoring indicates that Moffat Creek is currently in a poor ecological state.
- Smaller, more isolated lowland forest fragments - BMAs 2 and 4. **Rationale:** While fencing and pest control would significantly benefit these fragments, their small size and relative isolation means there are fewer opportunities for creating ecological linkages.

17. CONCLUSIONS

Whakamana Te Waituna Charitable Trust commissioned Wildland Consultants Ltd to prepare a biodiversity management plant for the Waituna Catchment, which covers all terrestrial and freshwater environments on both private and public land. The focus of the plan is on the maintenance, protection and enhancement of indigenous biodiversity. Most of the catchment is under privately ownership and is characterised by land used for dairy farming. The Waituna Lagoon and adjacent areas of wetland habitats are located in the lower catchment, most of which is administered by the Department of Conservation. Small scattered fragments of indigenous lowland forest and wetland habitats occur on private land in the mid to upper catchment, some of which are legally protected under QEII Trust covenants.

The health of the catchment is under significant pressure from current land uses. The Waituna Lagoon and the three major watercourses that discharge into the lagoon are subjected to high and frequent nutrient and sediment loading from surrounding farm land. Consequently, the lagoon is at risk of undergoing a 'regime shift' from a macrophyte-dominated system to an algal-dominated system. Such a shift may not be reversible, and would have catastrophic cascading impacts on biota and ecosystem functions. Other habitats throughout the catchment are also under threat from pest animals and plants, hydrological modifications, and ongoing clearance for agriculture.

To address these challenges, Wildlands has proposed four Biodiversity Management Areas (BMAs), which are based on factors such as ecosystem type, threats, and current and future management requirements. A range of technical reports and working papers have been used to inform the objectives, targets, and management recommendations for the proposed BMAs, particularly for the larger, more prominent sites such as Waituna Lagoon and Waituna Creek. Current projects in the catchment have also been mapped and described.

Central to the health of the Waituna catchment are water quality and hydrology. Priority should therefore be given to projects that aim to protect and enhance watercourses, restore connectivity with floodplains and wetlands, and reduce nutrient and sediment loads. The lagoon opening regime should also be continued in order to flush out nutrients, although further investigation is required regarding the timing and location of the openings in order to avoid damaging *Ruppia* macrophyte communities. There is a large body of literature that underscores the importance of *Ruppia* in coastal lagoon ecosystems; in the Waituna Lagoon, *Ruppia* is a keystone species upon which numerous other biota depend.

Other key management recommendations for the catchment include:

- Fencing and legal protection of all lowland forest and shrubland remnants, prioritising larger remnants in close proximity.

- Fencing and legal protection of all wetland remnants. Engage with landowners to identify and protect all wetlands in agricultural land (including small, degraded systems dominated by exotic plants).

- Expand existing pest animal and plant control so that it can be carried out a landscape scale, with a focus on the lower catchment which supports most of the indigenous habitats and values.

- Engage with landowners to investigate the potential of establishing ecological linkages between larger forest and wetland remnants in the lower catchment.

- Engage with landowners to explore the potential of establishing a landward buffer along the Waituna Lagoon. This could possibly link in with plantings undertaken by the Department of Conservation near Craws Creek.

Climate change and its associated impacts such as sea level rise, increased storm intensity and frequency, drought, and fire will have significant implications for natural habitats in the catchment. Sea level rise, in particular, has the potential to fundamentally alter macrophyte communities and intertidal habitats within the lagoon. Research and modelling (currently in draft form, see Tait 2018) has recently been carried out to help understand the potential effects of climate change in the Whakamana te Waituna project area.

The current projects and proposed projects and recommendations, if implemented in a timely manner, should markedly improve aquatic and terrestrial habitats alike, together with the biota they support, and help to build resilience against climate change. To be successful, however, extensive consultation with landowners, iwi, local authorities, Fonterra, and other key stakeholders will need to be undertaken in the short-term.

The Waituna Lagoon is at the heart of the project area, and its significance as a repository of biodiversity, Ramsar site, and taonga to Ngāi Tahu cannot be overstated. Meaningful action needs to take place now, otherwise there is a risk of irreversibly degrading one of New Zealand's most important coastal lagoon ecosystems.

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APPENDIX 1

FUTURE RISKS TO THE WAITUNA CATCHMENT

Overview

While the full suite of pest mammals is present in the Waituna catchment (and will be for the foreseeable future), the relative isolation of the Waituna catchment has meant there is a relatively low abundance and diversity of pest plant species. Similarly, pest fish species are restricted to just one species: brown trout (*Salmo trutta*). However, an increase in temperature and milder winters brings the prospect of novel pathogens, weeds, and invertebrates establishing in the catchment, with potentially important consequences for indigenous biodiversity. Warming temperatures may also facilitate the spread of existing pest plant species throughout the landscape. In addition, increased agricultural development together with a growing population, and perhaps more tourists, increases the risk of future pest introductions throughout the catchment.

This section discusses and priorities the key future risks to the catchment.

Climate Change

Coastal wetlands are also vulnerable to submergence due to sea-level rise, as shown by predictions of up to 80% of global wetland loss by the end of the century (Craft et al., 2009; Day *et al*., 2008; Morris *et al*., 2002; Kirwan *et al*., 2010; van Wijnen and Bakker 2001). Sea level rise has already led to significant geomorphological changes of coastal systems, salinity intrusion in estuaries, and loss of associated wetlands around the world (Day *et al*. 2008).

Future climate change may have a number of effects on *Ruppia* and the general health of Waituna Lagoon. Increased frequency of strong winds from the west to south-west would increase the risk of uprooting macrophytes and sediment resuspension. Increased rainfall intensity could increase the load of nutrients and sediment to the lagoon; and sea level rise will likely increase salinity and water levels in the lagoon which could affect the opening regime (Stevens & Robertson 2007; Robertson and Funnell 2012). In the event of sea level rise the long-term future of the lagoon will depend on allowing water levels when it is closed to move higher, so as to continue to provide habitat and continue to allow potential for flushing nutrients when it is opened (LTG 2013).

The lagoon area is projected to increase for both low and high tidal levels, but low tide area is projected to increase more than high tide area resulting in a decline in the intertidal wetted area from around 700 hectares to between around 400 to 230 hectares, depending upon the sea level rise scenario (Tait 2018).

Based on a study by Collins and Zammit (2016), mean discharge into Waituna Lagoon is projected to increase by up to 20% by mid-century and by up to 60% by the end of the century, compared with present-day. Most of this increase will be in autumn, winter and spring. The mean annual low flow (MALF) for the Waituna catchment is projected to increase by up to 20% by mid-century but decrease by up to 40% by the end of the century, related to drier summers (Tait 2018). Such changes will have a dramatic effect on the amount and frequency of nutrients entering the lagoon if a business as usual scenario is applied to the catchment.

Drought is also a potential threat to aquatic habitats within the catchment. For example, in summer 2017/18, the main stem of the Waituna Creek dried up due to dry weather conditions (Zane Moss, Fish & Game, pers. comms. 2018). Such extremes are likely to become more common with climate change. Lowered water levels in watercourses (from drought and irrigation) pose major risks to aquatic life (Palmer et al, 2008). In agricultural catchments, lack of dilution and flushing results in higher loadings of nitrogen and phosphorus and increased bacterial contamination (Caruso 2001). Invertebrate communities are best sustained by steady water flows (Scarsbrook 2002) and fish are killed when populations are stranded from the main flow with no deep pool refuges (giant kōkopu and bullies).

Increased storm frequency and intensity will likely result in greater amounts of nitrate entering the Waituna Lagoon. The Waituna catchment is predominantly recharged by rainfall and has a thin groundwater resource. The majority of nitrate mass load is discharged during storm events through the Waituna Creek (Rekker & Wilson 2016).

Agricultural Development

Increasing agricultural development and intensification in the Waituna catchment has been implicated in the declining water quality and environmental health of the lagoon (Environment Southland 2012). Wetland loss is still occurring on private land in the catchment; councils are sometimes issuing retrospective consents for wetland clearance (Ali Meade, Environment Southland, pers. comms. 2018). A study by Tanner *et al.* (2015) found that wetlands on private land comprising 2-3% of the catchment are predicted to be able to remove 30-40% of nitrate-N in run-off. Suspended solids and particulate phosphorous would also be substantially removed. Further wetland loss through drainage therefore represents a significant loss in the potential for farmers to utilise wetlands as attenuation assets. The cost of converting recently drained areas back into wetland is likely to be met with considerable opposition by farmers (Tanner *et al.* 2015).

Pest Plant Species and Diseases

Invasive non-indigenous weeds are one of the biggest drivers of freshwater biodiversity loss (Anderson *et al*. 2014). In some parts of the country Indigenous aquatic species have been completely replaced by invasive species in some parts of the country, e.g. lower Waikato area (Howard-Williams & Davies 1988). Aquatic pest plants such as hornwort (*Ceratophyllum demersum*) grow prolifically in response to excess nutrients, and are thus a major risk to high nutrient aquatic systems in the Waituna catchment. The key vector for the spread of aquatic pest plants is people; either through deliberate (e.g. ornamental ponds, release of aquarium contents) or accidental spread, e.g. contaminated boats, trailers, and nets.

Existing pest plant species such as grey willow have the potential to significantly increase their range throughout wetland habitats in the catchment. Terrestrial and wetland habitats are also vulnerable to invasion by wilding pine spreading from plantation forests. South African oxygen weed (*Lagarosiphon major*) was found in Waituna Lagoon in early 2016. While the weed will not survive in the lagoon, it is a major concern that it was found in the Waituna catchment. This aquatic pest plant can choke and block lakes and rivers. It is currently not widely established in Southland, and vigilance is required so that it does not spread.

Following the exclusion of stock from lowland forest remnants, the understorey will rapidly recover. However, a greater density and complexity of habitat in the understorey and ground tiers can result in an increase in ship rat numbers, given the increased availability of fruit and invertebrates.

Climate change will increase the likelihood of subtropical invertebrates establishing that pose risks to indigenous plants (Groenteman 2013). In addition, the establishment of vectors (e.g. ticks, mosquitoes, plant-sucking insects) could facilitate the spread of animal and plant diseases (Kean *et al*. 2015). One of the most serious plant diseases in New Zealand is myrtle rust (*Austropuccinia psidii*), a windborne plant pathogen that affects plant species in the Myrtaceae (myrtle) family. All myrtle species (introduced and indigenous) found in New Zealand are considered to be potential hosts for myrtle rust (Teulon *et al.* 2015). In the Waituna catchment, mānuka is a common myrtle species in wetland and shrubland habitats. If mānuka was adversely impacted by myrtle rust, the composition of plant communities would likely change as other plant species colonise following the release of competitive constraints. Myrtle plant species in Southland are currently less vulnerable to myrtle rust due to the harsh winters and lower annual average temperature, although the level of risk is likely to rise as the climate warms.

Novel Pest Fish Species

New Zealand is considered one of six global hotspots for exotic fish introductions, comprising >25% of all freshwater fish species present (Leprieur *et al*. 2008), and their numbers have steadily increased over time. Exotic freshwater fish are highly adaptable, frequently invasive, difficult to detect and notoriously difficult to eradicate. Koi carp (*Cyprinus carpio*), gambusia (*Gambusia affinis*), rudd (*Scardinius erythrophthalmus*), and brown bullhead catfish (*Ameiurus nebulosus*) are the invasive fish most frequently listed in regional council pest management plans (Collier & Grainger 2015). The inadvertent introduction of any of these species could have significant implications for indigenous fish, invertebrate and plant communities in the Waituna catchment, many of which are already under pressure from land-based activities. The key adverse effects that novel invasive freshwater fish could have on aquatic biodiversity in the Waituna catchment include direct predation on indigenous fauna, competition for food and habitat, resuspension of sediment and nutrients during feeding, and modification of invertebrate communities. Species such as koi carp can significantly reduce the abundance and diversity of indigenous macrophytes, which in turn gives invasive macrophytes, such as hornwort, a competitive advantage (Rowe & Smith 2001).

Soils and Nutrient Leaching

The soils and related surface drainage network have a large influence on nitrogen migration pathways, and there is evidence that areas of the Waikiwi soil type in the upper catchment are associated with the infiltration of significant loads of nitrogen to the aquifer. The Waikiwi soils are prone to nutrient loss through drainage, and more likely to drain to groundwater, and nitrate accumulation is elevated beneath areas of Waikiwi soils (Rekker & Wilson 2016).

High Priority Recommendations

High priority should be given to the prevention of novel aquatic pest plant species establishing in the catchment. Prevention is by far the cheapest and most effective option.

Once aquatic pest plants are established, it can be extremely costly and difficult to contain or eradicate them. Prevention can be achieved by creating awareness of the potential threats on local biodiversity amongst members of the public and land owners (e.g. cleaning boats and kayaks) as well as limiting public access to high value areas.

Monitoring is an important tool for detecting novel pest species and new incursions of existing pest plants. Monitoring will also be essential in assessing the impacts of climate change and sea level rise on plant communities in the Waituna lagoon.

Given the potential for wetlands on private land to attenuate the effects of nutrients and sediments on downstream habitats, it should a high priority to consult with farmers to (i) highlight the importance of wetlands on their land and (ii) discuss the possibility of restoring (or constructing) previously drained wetlands. The latter option will most likely require stakeholders such as Environment Southland, the Department of Conservation, and Fonterra to make financial contributions.

Moderate Priority Actions

Waituna Lagoon is a popular trout fishing destination for locals and tourists. While brown trout is the only introduced species known to be present in the lagoon, there is the potential for people to illegally release species such as rainbow trout and coarse fishing species such as perch and rudd. The Department of Conservation needs to ensure that adequate signage and information is visible to visitors, clearly explaining the threats that pest fish species have on indigenous freshwater ecosystems.

APPENDIX 2

INFORMATION GAPS AND REQUIREMENTS FOR FURTHER RESEARCH

Lagoon Opening Regime

While lagoon opening events cause extreme changes in water depth and salinity that can limit macrophyte growth, they also provide a mechanism to reduce the effects of eutrophication. Understanding these trade-offs is pivotal in management decisions regarding the likely impact of opening events on the ecological character of coastal lagoons (Robertson & Funnell 2012). The Lagoon Technical Group (2013) recommends using Walker's Bay as the standard opening location, although experimental openings should be investigated further to determine whether alternative opening locations could reduce the threat to aquatic vegetation communities while extending flushing benefits to other parts of the lagoon.

Soils and Nutrient Leaching

A study by Rekker and Wilson (2016) identified several information gaps regarding soils in the project area:

- The study used S-Map New Zealand Soil Database as a guide which was developed at a regional scale and is therefore not sufficiently accurate to fully capture soil distribution and leaching characteristics in the Waituna catchment.
- There are conflicts and inconsistencies between databases and the characteristics of certain soil types (e.g. Waikiwi was not identified within the S-Map database as vulnerable to nitrate leaching, but is classified as vulnerable to leaching in the Topoclimate database).
- It is difficult to distinguish Waikiwi soils from other brown soils in the region.
- The authors found the mechanisms for nitrate nitrogen infiltrating to groundwater, seeping into creek water, and the timing of these processes differ from those of the original Mokotua Infiltration Zone concept (the most recent groundwater technical report on the Waituna catchment prepared by Rissman *et al*. 2012).
- Characterising artificial drainage practices and densities has lagged behind soil and groundwater studies, making it difficult to correlate soil drainage properties and water table depth.

To help address these gaps, Rekker and Wilson (2016) recommend the following measures:

1. Continuous nitrogen monitoring

   Improve monitoring in key areas, where data is insufficient to determine nitrate source areas definitively. Based on available data, the contribution of different sources is unclear and this requires high-resolution monitoring of nitrate and flow at key locations. The study recommends using optical nitrate nitrogen data-logging sensors and that paired flow and nitrate sensor monitoring should be carried out during autumn and winter at

Rimu-Seaward Downs Road, Waituna Road, and the (Invercargill-Gorge Road) Highway.

2. Characterisation of soil

   Further work is needed to detail soil characterisation in the catchment. The available information was inaccurate and inconsistent between sources, and the types of soil within the catchment are difficult to distinguish. The authors recommend identifying and mapping soils that are most vulnerable to nitrate leaching if the land were to be retired from dairy farming.

Aquatic Fauna

Surveys should also be carried out to locate inanga spawning sites, which are currently unknown (Stevie-Rae Blair, Te Ao Marama/te Rūnanga o Awarua, pers. comms. 2018). Similarly, it would be beneficial to undertake surveys of potential giant kōkopu spawning habitat. If spawning sites for these fish species can be located, targeted control of rodents should be carried out in order to protect vulnerable eggs.

Invertebrates

The abundance and diversity of invertebrates are good indicators of ecosystem health and function. Further invertebrate surveys are required as not all areas in the Waituna project area are adequately covered in all seasons. A focus of the surveys would be the inter-relationships between insects, plants and habitats, noting that mixing of upland and lowland invertebrate species in the general area (Tiwai-Seaward Moss-Waituna) is unique in New Zealand. It is also recommended that the monitoring of key species is continued, e.g. threatened moth species such as *Asaphodes frivola*.

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Call Free 0508 WILDNZ
Ph: +64 7 343 9017
Fax: +64 7 3439018
ecology@wildlands.co.nz

99 Sala Street
PO Box 7137, Te Ngae
Rotorua 3042,
New Zealand

Regional Offices located in
Auckland, Hamilton, Tauranga,
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