EVALUATION OF RESTORATION MANAGEMENT REQUIREMENTS AT MIRANDA - PUKOROKORO

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EVALUATION OF RESTORATION MANAGEMENT REQUIREMENTS AT MIRANDA - PUKOROKORO

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Project Team:

Richard Gillies - Report author, field assessment
William Shaw - Report author, field assessment
Federico Mazzieri - GIS and mapping

Prepared for:
Department of Conservation
PO Box 20025
Hamilton 3241

99 SALA STREET, WHAKAREWAREWA, 3010, P.O. BOX 7137, TE NGAE, ROTORUA 3042
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:

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W.B. Shaw
Director/Principal Ecologist
Wildland Consultants Ltd

1. INTRODUCTION

The Department of Conservation and Fonterra have formed a partnership - the Community Investment in Water programme - which aims initially to improve water quality in five sensitive catchment areas, one of which is the Firth of Thames. This report forms part of a range of investigations to consider how best to undertake wetland restoration in the Miranda-Pukorokoro catchment[1] especially where such restoration relates to shorebird habitat improvement. Specific land within the scope of the project includes, but is not necessarily limited to:

- Land administered by the Department of Conservation, including the "McCartie Block", recently acquired through a Nature Heritage Fund purchase.
- Land owned and/or managed by the Miranda Naturalists Trust (MNT).
- Private land adjacent to the coast owned/managed by Glen Isla Farms Ltd (the Lane family) - the Finlay QEII covenant.
- Private land adjacent to lower reaches of the Miranda Stream and the Pukorokoro Stream and East Coast Road (i.e. the Coxhead and Dalton properties).

This report provides an overview of the ecological context, vegetation and habitats, species of note, an overview of ecological values, and restoration management issues and opportunities.

2. METHODS

- A base map was prepared using relevant recent aerial photography and other digital data.
- Relevant existing hard copy and digital data and information was collated, including relevant records held by the Miranda Naturalists Trust, District Council, Waikato Regional Council, and the Department of Conservation.
- All relevant existing ecological information within the local area was reviewed.
- Topo50 streams data was overlain with Landcover Database (LCDB3) cover classes to obtain an estimate of the total length of streams within the Miranda-Pukorokoro catchments.
- Ecological values within and adjacent to the study area, including terrestrial and aquatic systems, were identified and ranked.
- A field visit was undertaken on 10 February 2014, and observations and findings were subsequently used to:
  - Map and identify land units within the wider study area.

[1] For the purposes of this study the Miranda catchment area includes the Hauarahi Stream, at Kaiaua, the Miranda Stream, and all stream catchments in between.

- Assess actual and potential ecological values within each subject land unit.
- Identify management requirements to restore or enhance ecological values, having particular regard to shorebirds.
- Identify requirements for resource consents, restoration/operational plans, physical works.
- Identify likely costs for each component identified above.
- Tabulate above for each subject land unit.

3. ECOLOGICAL CONTEXT

3.1 Overview

The broader area of interest is the series of stream catchments that drain the western side of the Firth of Thames between the settlements of Kaiaua and Miranda. For convenience in the rest of this report, this area is referred to as 'Miranda-Pukorokoro'. Named streams along this section of coast include the Miranda Stream, Pukorokoro Stream, Taramaire Stream, Te Puaeharuri Stream, and the Hauarahi Stream. These catchments span the Hunua, Hapuakohe and Hauraki Ecological Districts. Overview information on each of these Ecological Districts is provided in Table 1 below.

Table 1: Character of Ecological Districts relevant to the Miranda coast catchments.

Ecological District	Indigenous Vegetation (ha)	% of Total	Culturally-Derived/Exotic Vegetation (ha)	% of Total	Total (ha)
Hunua	29,145	43.0%	38,659	57.0%	67,804
Hapuakohe	12,090	16.4%	61,613	83.6%	73,703
Hauraki	11,838	15.3%	65,470	84.7%	77,309

3.2 Hauraki Ecological District

Hauraki Ecological District would once have contained vast alluvial wetlands and kahikatea (*Dacrycarpus dacrydioides*) forest. Forest clearance, then drainage and management of the Piako, Waihou, and Waitakaruru Rivers has resulted in overwhelming modification and conversion to intensive pasture-based farming, the main exception to this pattern being the *c.*10,000 ha Kopuatai peat dome. These rivers are the main catchments disgorging into the Firth of Thames, especially the internationally important Ramsar wetland site at the southern end of the Firth, which is bounded by coastal areas in Hauraki Ecological District.

Notable areas within the Miranda-Pukorokoro project area include the coastal chenier plain and a 7,000-year-old scarp *c.*0.5-2 km inland that denotes the pre-chenier shoreline.

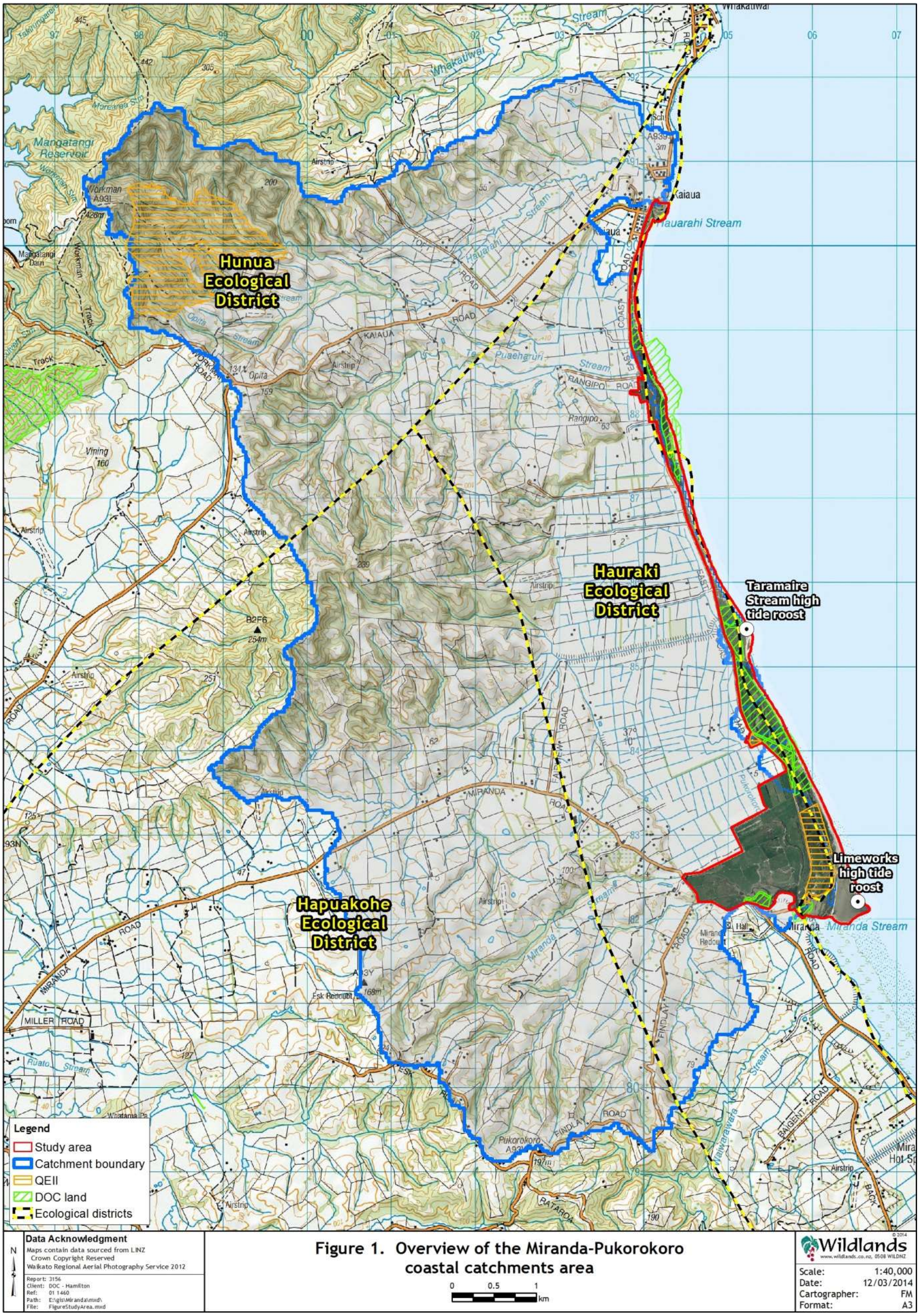

Figure 1. Overview of the Miranda-Pukorokoro coastal catchments area

3.3 Hapuakohe Ecological District

Characterised mainly by mixed-age sandstone and siltstone hill country extending from near sea level to 535 m in altitude including some eroded extinct andesite volcanoes. On the higher hills some substantial areas of indigenous forest remain, as well as exotic plantation forest, but pasture-based farming is predominant.

Within the Miranda-Pukorokoro project area there is a series of low hills to 239 m a.s.l., with easier country in pasture and indigenous forest and scrub in many of the stream gullies.

3.4 Hunua Ecological District

Hill country to 688 m a.s.l on strongly weathered sedimentary (mainly greywacke) substrates. Lower altitude and coastal areas have been extensively developed for pasture-based farming. Higher altitude, inland areas are covered in indigenous forest and scrub, much of it secondary, as well as exotic plantation forest.

Within the Miranda-Pukorokoro area there are forested headwaters of the northern streams, which supply greywacke gravel to the northern portion of the coastal chenier plain, and the farmed foothills.

3.5 Wetlands within the Miranda-Pukorokoro coast catchments

Natural wetlands would have originally covered a much greater extent on the low-lying chenier plain, but these have been much modified and reduced in size by the network of drains that covers the entire plain and the resulting pasture-based farming that is currently the dominant land use. Remaining natural wetlands are largely restricted to small estuarine areas around the mouths of the major streams, as well as the intertidal flats along the coastline.

4. VEGETATION AND HABITATS

Chenier Plains

Shell barrier beaches, or chenier plains, consist of low ridges composed of shells and sand overlying marine sediments, formed by a combination of longshore drift and wave action on sheltered coastlines. Only around 12 chenier plain systems have been identified globally, and in New Zealand chenier plains are confined to the Hauraki Gulf and Waitemata Harbour. The coastline at Miranda-Pukorokoro has the most extensive chenier plain system in New Zealand, and is the only known example, globally, of a chenier plain that is currently aggrading (Clarkson *et al.* 2014). The most seaward chenier formed around 1969 and has advanced *c*.1.5 km southward and parallel to the previous shoreline (Hayward B.W., in MNT 2013).

The Miranda-Pukorokoro chenier plain system is regarded as an internationally-important geopreservation site. The following is reproduced from the New Zealand Geopreservation Inventory (http://www.geomarine.org.nz/NZGI/):

- Classification A1: A = International Importance; 1 = vulnerable to complete destruction by human actions

- Significance: internationally important area for study of chenier plain development in a tectonically stable progradational coast. Only known occurrence in the world of a chenier plain gravel ridge association (in conjunction with the Whakatiwai gravel ridges)

Chenier plains have been identified as one of 72 New Zealand ecosystems regarded as naturally uncommon (Holdaway *et al.* 2012) by virtue of having an estimated extent prior to human colonisation of <0.5% of New Zealand's land area (<*c*.134,000 ha). Holdaway *et al.* (2012) assigned the highest level of threat - Critically Endangered - to chenier plain ecosystems in New Zealand (see Table 2 below for the full assessment), noting also that there has been widespread loss of indigenous woody vegetation cover.

Table 2: Threat assessment for chenier plain ecosystems (Holdaway *et al.* 2012).

Criterion	Critically Endangered Factors	Threat(s)[1]	Indicator(s)[1]
B2: Historical decline in ecological function.	Very severe decline throughout >90% of extant distribution.	A, B, R, W	I, E, Cp
C2: Small current distribution and (area of occupancy) and decline, or very few locations.	Area of occupancy ≤10 km^2 and: a) Continuing decline in distribution b) Continuing reduction in ecological function.	A, R, W	E
D: Very small current distribution (area of occupancy) and serious threats.	Area of occupancy ≤5 km^2 and serious plausible threats.	A, R, W	E

1. Threat descriptors: A = agriculture, B = fire, W = invasion by non-indigenous plants, R = residential development.
2. Indicators of declines in ecological integrity (Table 2): I = indigenous vegetation cover, E = non-indigenous plant and animal abundance, Cp = composition (plants).

Vegetation Pattern

A vegetation survey (Merrett and Clarkson 1997) mapped seven vegetation and habitat types across the area seaward of East Coast Road:

- Mangrove forest
- Bare shell banks
- Glasswort saltmarsh herbfield
- Batchelors button-*Mimulus repens* herbfield[1]
- *Carex divisa* sedgeland
- Rye grass-bur medic grassland
- Saltmarsh ribbonwood-*Coprosma propinqua* shrubland

[1] Structural class has been added, where missing from original vegetation types.

Major changes evident since the 1997 map was compiled have been the southwards extension of mangroves along the small tidal creek on the landward side of the active chenier shell bank, the dominance of fennel in nearly all ungrazed drier pasture areas (more or less 1997 Vegetation Type 6 - rye grass-bur medic grassland), and the small-scale planting of shrubs on a fenced strip along East Coast Road east to the north of the MNT shorebird centre.

5. THREATENED, AT RISK, OR REGIONALLY UNCOMMON SPECIES

A 'Bioblitz' held on 28 February 2013 recorded 1,132 species or 'recognisable taxonomic units' across 69 classes of animals, vascular and non-vascular plants, invertebrates and bacteria (P. Maddison, unpubl. data).

Birds (shorebirds, waders, waterfowl and wetland birds) regularly seen at Miranda-Pukorokoro (see http://www.miranda-shorebird.org.nz/shorebirds-at-miranda) are listed in Table 3, as well as other indigenous fauna known to be present, and At Risk or regionally uncommon or distinctive plants. The Firth of Thames is an internationally important non-breeding site for seven shorebird species (highlighted in Table 3), and the Miranda-Pukorokoro coast contains the most important high tide roosts for these species.

Table 3: Shorebirds, wetland birds, waterfowl, and other Threatened, At Risk, or regionally uncommon fauna and vascular plants known from the Miranda coast. The Firth of Thames is internationally important for the species highlighted in green.

Combined Threat Classification[1]	Taxon	Common Name	Status at Miranda-Pukorokoro/Firth of Thames[2]
Vascular Plants			
At Risk-Naturally Uncommon	*Mimulus repens* R.Br.		Regionally uncommon. Miranda-Kaiaua is the Auckland-Waikato stronghold for this species.
Not Threatened	*Ileostylus micranthus*		Regionally uncommon. Present in a narrow strip of saltmarsh shrubland on the seaward side of East Coast Road just north of shorebird centre.
Birds			
Threatened-Nationally Critical	*Ardea modesta*	White heron	U
	Himantopus novaezelandiae	Black stilt	R; Internationally important. Winter flock site for >1% of total species population (Dowding and Moore 2006)
	Larus bulleri	Black-billed gull	C; breeding
	Thinornis novaeseelandiae	New Zealand shore plover	V; one individual present last two years

[1] Birds - Robertson *et al.* (2013); reptiles - Hitchmough *et al.* (2013); freshwater fishes - Allibone *et al.* (2010); vascular plants - de Lange *et al.* (2013).

[2] A=Abundant, C=Common, U=Uncommon, R=Rare, V=Vagrant.

Combined Threat Classification[1]	Taxon	Common Name	Status at Miranda-Pukorokoro/Firth of Thames[2]
Threatened-Nationally Endangered	*Botaurus poiciloptilus*	Bittern	U; breeding
Threatened-Nationally Vulnerable	*Anarhynchus frontalis*	Wrybill	A; *c*.2,000 bird, or 40% of total species population winters at Firth of Thames - internationally important site and critically important to the species.
	Calidris canutus rogersi	Lesser Knot	A; Internationally important site. *c*.6,300 birds present in summer. *c*.10% of NZ population (Melville and Battley 2006).
	Charadrius bicinctus bicinctus	Banded dotterel	A
	Charadrius obscurus aquilonius	Northern New Zealand dotterel	C; breeding. Internationally important site. Winter flock site for >1% of total species population (Dowding and Moore 2006).
	Phalacrocorax varius varius	Pied shag	A
At Risk-Declining	*Gallirallus philippensis assimilis*	Banded rail	C; Breeding
	Haematopus finschi	New Zealand pied oystercatcher	A; Internationally important site for *c*.10% (*c*.13,000 birds) of species population. (Melville and Battley 2006).
	Himantopus himantopus leucocephalus	Pied stilt	A; Internationally important. Biggest NZ wintering site, *c*.3,300 birds, *c*.10% of total NZ population (Dowding and Moore 2006, Melville and Battley 2006).
	Limosa lapponica baueri	Eastern bar-tailed godwit	A; internationally important site. *c*.5,500 birds are present in summer. *c*.5% of NZ population population (Melville and Battley 2006).
	Sterna striata striata	White-fronted tern	A
At Risk-Recovering	*Haematopus unicolor*	Variable oystercatcher	C
At Risk-Naturally Uncommon	*Phalacrocorax carbo novaehollandiae*	Black shag	A
	Phalacrocorax sulcirostris	Little black shag	A
	Platalea regia	Royal spoonbill	C
Not Threatened	*Anas gracilis*	Grey teal	A
	Anas rhynchotis variegata	New Zealand shoveler	C
	Egretta novaehollandiae	White-faced heron	A
	Larus dominicanus dominicanus	Southern black-backed gull	A
	Phalacrocorax melanoleucos brevirostris	Little shag	A
	Porphyrio melanotus melanotus	Pukeko	A
	Stictocarbo punctatus punctatus	Spotted shag	C
	Todiramphus sanctus vagans	Sacred kingfisher	A

Combined Threat Classification[1]	Taxon	Common Name	Status at Miranda-Pukorokoro/Firth of Thames[2]
	Vanellus miles novaehollandiae	Spur-winged plover	A
Non-resident Native-Migrant	*Ardea ibis coromanda*	Eastern cattle egret	C
	Arenaria interpres	Turnstone	C
	Calidris acuminata	Sharp-tailed sandpiper	C
	Calidris ruficollis	Red-necked stint	C
	Numenius madagascariensis	Far-eastern curlew	R
	Numenius phaeopus variegatus	Asiatic whimbrel	U
	Pluvialis fulva	Pacific golden plover	C
Non-resident Native-Vagrant	*Calidris ferruginea*	Curlew sandpiper	U
	Calidris melanotos	Pectoral sandpiper	U
	Charadrius leschenaultii leschenaultii	Large Sand Dotterel	U
	Charadrius semipalmatus	Semi-palmated plover	V
	Tringa cinerea	Terek Sandpiper	U
	Tringa stagnatilis	Marsh sandpiper	U
Reptiles			
Not Threatened	*Oligosoma smithii*	Shore skink	Known from Taramaire Reserve and other locations along the outer shell bank.
Freshwater Fish			
At Risk-Declining	*Anguilla dieffenbachii*	Longfin eel	Present in freshwater lagoon on McCartie property.
	Galaxias maculatus	Inanga	Present in freshwater lagoon on McCartie property.

6. ECOLOGICAL VALUES

6.1 Overview

The very high ecological values of the Miranda-Pukorokoro area include:

- International importance as the most important high-tide wader roost in the Firth of Thames Ramsar site, including multiple Threatened and At Risk wader species (Battley *et al.* 2007). It meets Ramsar Criterion 5 (regularly supports >20,000 waterbirds), and Criterion 6 (regularly supports >1% of a population of a species or sub-species of waterbird.

- Habitat for a range of other Threatened, At Risk, or regionally uncommon bird and plant species (Miranda Naturalists' Trust 2013).

- Status as the largest example of a chenier plain ecosystem in New Zealand; a naturally uncommon ecosystem classified as Critically Endangered (Holdaway *et al.* 2013).

- The chenier plain is regarded as an internationally important geopreservation site (Hayward 2013).

6.2 National priorities for protection of biodiversity on private land

Collectively, the ecological values of the Miranda-Pukorokoro area meet all four national priorities for protecting biodiversity on private land (MfE 2007), which are used to guide conservation effort and identify funding priorities. Areas of indigenous vegetation and habitats of indigenous fauna which meet any of the four priorities are regarded as significant by the Proposed National Policy Statement on Indigenous Biodiversity. The four priorities are:

- Presence of Acutely Threatened or Chronically Threatened land environments (Walker *et al.* 2006): virtually the entire Miranda-Kaiaua chenier plain has the highest threat category - Acutely Threatened - signifying that indigenous vegetation cover is <10% of the total area of the underlying land environments.

- Presence of sand dunes and wetlands: the Miranda-Pukorokoro area contains high quality areas of estuarine saltmarsh and intertidal flats, part of the internationally important Firth of Thames Ramsar site.

- Presence of Naturally Uncommon ecosystems (Holdaway *et al.* 2012): the Miranda-Pukorokoro chenier plain is a Naturally Uncommon ecosystem with the highest level threat classification, Critically Endangered. Estuarine areas occur along the coast, especially in the shallow depressions between the chenier ridges, as well as at the mouth of the Miranda and Pukorokoro Streams. Estuary ecosystems are also regarded as naturally uncommon, and have the third highest threat classification, Vulnerable.

- Presence of Threatened and At Risk species (Townsend *et al.* 2008): Ten Threatened bird species, nine At Risk bird species, two At Risk freshwater fish, and one At Risk plant species are present within the Miranda-Pukorokoro area. For several taxa, notably wrybill, eastern bar-tailed godwit, and red knot the Miranda-Pukorokoro area represents important habitat for substantial populations or for a substantial percentage of the total population.

7. RESTORATION ISSUES AND OPPORTUNITIES

7.1 Overview

The focus of this assessment is on securing shorebird habitat, noting that wider ecological and natural heritage values also need to be considered. These wider values revolve around the chenier plain landform and its highly threatened and under-represented terrestrial and wetland ecosystems, which rank very highly in the context of biodiversity and ecosystem conservation in New Zealand. Ecological values, management issues and options identified at Miranda-Pukorokoro are interlinked to a large extent, and will be difficult to manage in isolation. All of the management issues and options discussed here have been previously identified and discussed to different degrees, e.g. Strahan 1997, Merrett and Clarkson 1997, Battley *et al.* 2007, Brownell *et al*. 2008, Benham 2012, Golder 2014, and by the Miranda Naturalists Trust in general.

As a very important driving force in highlighting and advocating for protection of the natural values of the Miranda-Pukorokoro area, the Miranda Naturalists' Trust recently facilitated discussions among agencies and experts on how to better coordinate management of the entire coastal strip (MNT 2013), from which an overall vision and several contributing objectives were formulated (Table 4 below). These have been used as a working framework for examination of the various management options that might potentially be implemented at Miranda.

Table 4: Working vision and objectives for the Miranda-Pukorokoro coast (adapted from MNT 2013).

Vision:	To maintain and enhance the coastline habitat from Miranda to the Taramaire bird roosts		
Objectives:	Maintain safe roosting habitat around the high tide bird roosts on a long-term basis	Maintain and enhance/extend existing saltmarsh vegetation.	In various appropriate areas between the Taramaire and Miranda roosts, establish or enhance a mosaic of habitats that will encourage wader breeding, increase habitat for banded rail and bittern, lizards, invertebrates, and the reintroduction of fernbird and any other appropriate indigenous bird species.

7.2 Current management issues

7.2.1 High tide shorebird roosts

The main high tide wader roosts along the Miranda-Pukorokoro coast are the Limeworks, comprising the outer shell bank and the adjacent Stilt Ponds at the mouth of the Miranda and Pukorokoro Streams, and Taramaire, comprising the shell banks either side of the Taramaire Stream mouth. At both roosts, on the very highest tides, shorebirds also utilise the adjacent paddocks either side of East Coast Road (Battley *et al.* 2007). The Limeworks site is the larger of the two in terms of shorebird roosting numbers. The Limeworks and Taramaire sites are now the main high tide roosts in the Firth of Thames.

Since 1960, expansion of mangroves along the southern shoreline of the Firth of Thames has effectively covered three previous major wader roosting areas, at Piako, Waitakaruru, and Karito. Disturbance by campervans, 4WD vehicles, and horses has degraded what was previously a high tide roost between Taramaire and Rangipo (Battley *et al.* 2007). There is therefore a need to create additional high tide roosting areas. Desirable attributes for spring high tide roosts include:

- Close proximity to normal hide tide roosts (to minimise commuting flights and conserve energy);
- A mixture of dry land and shallow ponds to address the varied requirements of different shorebird species.
- An area of shallow (<75 mm depth) water, periodically recharged to maintain water quality and depth.
- Short stature vegetation on dry parts of the roost, with at least 50 m visibility;

- Minimal disturbance from stock or human activity.
- Maintaining these conditions during the period September-April (D. Lawrie, Miranda Naturalists Trust, pers.comm.).

7.2.2 Saltmarsh vegetation

Saltmarsh vegetation in the Miranda-Pukorokoro area has been heavily affected by human activity, especially alterations to hydrology resulting from extensive drainage systems, flap-gated culverts and stopbanks (e.g. on the Pukorokoro and Miranda Streams), road construction, grazing, and weed invasion. Upper level saltmarsh shrubland characterised by saltmarsh ribbonwood (*Plagianthus divaricatus*), pohuehue (*Muehlenbeckia complexa*), mānuka (*Leptospermum scoparium*), and flax (*Phormium tenax*) has largely disappeared except where it has been maintained by planting and fencing. Salt meadow plant communities have been adversely affected by grazing and mangrove expansion, and *Mimulus repens* herbfields have largely (but not entirely) been out-competed by rank grass when stock have been excluded.

7.2.3 Habitat diversity

The main vegetation community that is now 'missing' from the Miranda-Pukorokoro coastal strip is the shrubland and scrub that would formerly have covered the drier, inland chenier ridges as well as the highest and least inundated areas of saltmarsh. These communities would have been dominated by manuka, saltmarsh ribbonwood, and *Coprosma propinqua*, as well as cabbage tree (*Cordyline australis*) and flax. This scrub and shrubland would have provided cover and breeding habitat for wetland birds such as banded rail (*Gallirallus philippensis assimilis*), spotless crake (*Porzana tabuensis tabuensis*), fernbird (*Bowdleria punctata*), and bittern (*Botaurus poiciloptilus*), as it currently does to a limited extent around the small ponds adjacent to the Shorebird Centre and on the other side of East Coast Road.

7.3 Future options

Various options and activities can be applied to improve biodiversity management at Miranda-Pukorokoro:

- Land acquisition and restoration;
- Grazing management;
- Water level manipulation;
- Predator control;
- Mangrove control;
- Advocacy and regulation;
- Catchment-level management.

These options and activities are addressed in the sections that follow.

Land acquisition and restoration is addressed in the various sections below relevant to this option. Further land can be added to the protected area network, to increase the area potentially available to indigenous biota. It is not necessarily imperative, however, to completely retire such land from grazing, as discussed below.

8. WATER LEVEL MANIPULATION

Water level manipulation can be used to increase/improve habitat for shorebirds, wetland birds, and saltmarsh vegetation.

Several parts of the coastal strip comprising ungrazed or low producing pasture are subject to drainage and/or water level management via culverts/flap-gates and drains, which aims to increase the ability of the catchment to drain freshwater, as well as prevent intrusion of salt water. The largest such area is on the Coxhead and Dalton properties, which is covered by a network of drains and stopbanks. The Pukorokoro Stream, which drains the northern part of these properties, has flap-gated culverts across its channel *c.*40 m from its confluence with the Miranda Stream. Upstream of the flap-gates only the channel of the main stream contained standing water. Natural side channels and constructed drains were dry and the muddy substrate was cracked when visited on 10 February 2014. In contrast, the Miranda Stream is stop-banked but there is no flap-gate. As a result there are more extensive areas of intertidal mudflats and glasswort-dominated herbfields, mainly in areas not accessible to stock.

A number of actions could be taken to restore appropriate parts of the Coxhead and Dalton properties to estuarine conditions, or to provide shallow roosting ponds that are periodically recharged with saline water:

- Periodically open the flap-gates to flood the land upstream to maintain a desired depth/extent, or
- Install a weir or pipe that floods only on spring high tides, or
- Removal of the existing flap-gate structures.
- Construction of new drains and construction of a new flap-gate further upstream, if required, to protect surrounding low-lying farmland.
- Recontouring of drains or excavation of shallow depressions to form ponds that will hold standing water over the summer months, when the shorebird population is at its highest.

To create a secure and workable long-term solution that addresses both restoration goals and the economic implications for affected farmland, it is likely that some combination of land purchase or formal protection would also need to occur.

There are some risks and uncertainties around undertaking this type of management, including:

- There is an incomplete understanding of the current flood control system (see Golder 2014) and how it can best be adapted to (a) accommodate a shore bird roost, and (b) minimise effects on land further upstream to be retained primarily for grazing.
- The extent to which it will be used by shore birds in the short term, and

- Uncertainty over longer-term coastal processes such as the rate and eventual distance of extension of the current chenier (which may shift the existing high tide roost away, over time, from the Miranda-Pukorokoro estuary), and the magnitude and rate and impact of sea-level rise.

A useful initial step would be to trial controlled opening of the flap-gates (using the estimated flow-rate and volume parameters in Golder (2014)), just prior to summer spring high tides, to gather information on:

- Whether the current system is configured to allow this to happen in a practical and controllable way.
- Where the water ponds currently and for how long.
- Where pond creation could occur with minimum effort.
- How many shorebirds and which species utilise the roost, compared to existing high tide roosts.

Overall, there would be considerable merit in this approach, although it should be noted that water level management will also need to be integrated with excavation of shallow ponds, ongoing grazing and/or mowing, and assessment of potential hydrological effects on land further upstream.

9. GRAZING MANAGEMENT

Grazing can be managed to provide high tide shorebird roosts, enhance *Mimulus* habitat, and to manage pest plant species.

Parts of the study area, particularly the Dalton, Coxhead, and McCartie blocks, are managed within operational farms. Other areas, particularly on the seaward side of East Coast Road, are only subject to low intensity intermittent grazing (grazing concessions within the Miranda Taramaire Wildlife Reserve have recently expired; S. Benham, Department of Conservation, pers. comm.). The most obvious feature of ungrazed pasture is the dominance of head-high fennel (*Foeniculum vulgare*), especially on the higher and drier ground. Little regeneration of indigenous woody terrestrial species appears to be occurring. Cattle are effective at grazing down the fennel and grass sward (see photographs attached), however, the grazing pressure needed to achieve short-stature vegetation to the water's edge suitable for high-tide roosting shorebirds may have negative impacts on the glasswort-dominant herbfields that would otherwise colonise the brackish, shallow ponds and stream channels, especially on the Dalton and Coxhead properties (see photographs attached), and will also have negative effects on water quality.

Conversely, grazing appears to be an important factor in maintaining habitat for *Mimulus repens*, either by removing the competing grass sward from wetland margins, and/or by stock trampling creating a gently-sloping, damp wetland margin (c.f. managed drains, which tend to be excavated with steep sides; Benham 2012). Similarly, inside a 20×8 m area fenced between 1984 and 2012, between the Limeworks and the outer shell bank, a grass sward developed with no regeneration of

woody plants, and it was noted that indigenous short-stature species characteristic of the area, such as *Mimulus repens*, were more prevalent in grazed habitat elsewhere at Miranda-Pukorokoro (MNT 2013).

Sheep (*Ovis aries*) may be a better alternative to cattle (*Bos taurus*) for grazing, mainly because they will cause less pugging of wet ground and damage to saltmarsh herbfield, and it may not be necessary to fence off lagoons and ponds. Areas to be grazed by sheep would, however, need to be topped by mower or grazed by cattle first. The main impediments to grazing with sheep are a lack, or absence, of local sheep flocks, so a flock may need to be purchased and managed specifically for the task, which may not be practicable or cost-effective.

There are other potential alternatives to grazing to maintain open shorebird roosting areas, however these all have potential obstacles to overcome:

- Mowing (somewhat rough and uneven ground);
- Spraying with herbicide (probably not suitable for sustained application around waterways);
- Weed-eating (labour-intensive and probably only feasible for small areas).

Merrett and Clarkson (1997) recommended development of a better understanding both of grazing impacts, and its utility as a conservation management tool at Miranda. The experimental design suggested was to use temporary fencing to create *c.*30 m wide strips extending from the road to the foreshore, within which different treatments could be trialed. This suggestion still has merit, but should also be compared with periodic mowing with a rotary slasher.

10. PREDATOR CONTROL

Predator control is already being used to increase the breeding success of various species.

The Miranda Naturalists Trust has undertaken predator control around the shell banks for the last four summers, primarily to protect nests of northern New Zealand dotterel, white-fronted tern, black-billed gull, and variable oystercatcher.

Predator species killed have included stoats (*Mustela erminea*), ferrets (*Mustela furo*), weasels (*Mustela nivalis vulgaris*), hedgehogs (*Erinaceus europaeus*), rats (*Rattus* spp.), and feral cats. Ongoing mammalian predator control may increase the breeding success of these species, but may not be necessary for their ongoing use of Miranda as a breeding area. Likewise it may reduce disturbance of non-breeding shorebirds, but the extent to which such disturbance affects their life cycles is unclear.

11. MANGROVE MANAGEMENT

Mangrove control has been used to maintain existing shorebird roosting and feeding habitat. The Miranda Naturalists Trust removes mangrove seedlings from the intertidal flats between the active end of the shell spit and the bird watching hide. The purpose of this work is to preserve foraging and roosting habitat for shorebirds within their principal high tide roosting area.

Mangroves have expanded rapidly from a restricted distribution in the mid-1940s around the mouths of the Waihou, Piako, and Waitakaruru Rivers, and now occupy around 1,100 ha of intertidal flats. This expansion has occurred several decades after the major period of land clearance, catchment management, and sediment deposition from the 1850s to the 1920s, suggesting that other factors may be involved, such as changes in climate and nutrient availability (Swales *et al.* 2007). The Miranda Stream represents the western margin of this area, where mature mangroves cover the southern side of the stream delta, and line the stream to *c.*1.3 km inland. Mangroves have also colonised the sediment-filled channels immediately inland of the seaward-most chenier, and saline areas of streams and drains throughout the project area.

It needs to be noted that, while this assessment mainly treats mangroves as a management issue in relation to the project area, they nevertheless also comprise a large, valuable, and major component of the Firth of Thames ecosystem.

12. INDIGENOUS REVEGETATION

Planting could be used to restore woody vegetation to dryland chenier plain ecosystem, provide habitat for wetland birds and other fauna, and increase abundance of host plants for *Ileostylus micranthus*.

Small-scale planting of coastal wetland vegetation - such as flax, cabbage tree, and woody shrubs - has occurred around the carpark to the Miranda Naturalists Trust bird-watching hide, around the Shorebird Centre, and along a narrow 600 m long strip on the landward side of the road immediately to the north of the centre. There is certainly potential to restore additional areas to a state approximating the pre-human forest and scrub cover but this should be done carefully, and with due regard to potential impacts on shorebird high tide roost habitat, as well as shorebird watchers, especially in the vicinity of the bird watching hide carpark and the roadside adjacent to the stilt ponds. The Access Bay ponds are likely to comprise the best sites for restoration planting given that wetlands are present, some planting has already occurred, and they are distant from the main Limeworks and Taramaire high tide roosts. The recently-acquired McCartie block is another site where restoration plantings are planned.

13. ADVOCACY AND REGULATION

Advocacy and regulation can be applied to protect shorebird roosts from human disturbance.

The Miranda-Pukorokoro coastline, and its two major shorebird high tide roosts have a high level of human access. A network of walking tracks enables access from the Limeworks through to Access Bay and the Shorebird Centre. The mown foreshore reserve north of Taramaire ('Ray's Rest) is a very popular freedom camping spot for campervans. The Miranda Naturalists Trust manages human disturbance through a combination of education, signage, and on-site wardens. At Ray's Rest the Hauraki District Council have made efforts to restrict vehicle access in proximity to the Taramaire Stream roost, and enforce the 'Dog-Prohibited Area' bylaw for the beach between Miranda-Pukorokoro and Kaiaua.

14. WIDER CATCHMENT MANAGEMENT

The quality and health of shorebird foraging habitat is closely linked to that of the intertidal areas of the wider Firth of Thames. There is evidence that multi-decade declines in some shorebird species populations (e.g. wrybill) in the Firth of Thames is related to degradation of intertidal foraging habitat by sediment deposited over more than a century of land clearance, river engineering, farming and mining (Battley *et al.* 2007).

Currently the largest contributors of sediment and nutrients to the Firth of Thames are the Waihou and Piako Rivers which, combined, drain 96% of the total Firth of Thames catchment area and contribute, per annum, *c.*185,000 tonnes of suspended sediment (Swales *et al.* 2007), *c.*3,700 tonnes of nitrogen, and *c.*261 tonnes of phosphorus (Vant 2014). The annual sediment inflow and its effects on inter-tidal zone ecology, are dwarfed, however, by the total amount of sediment calculated to have been deposited in the Firth of Thames since the 1880s (Swales *et al.* 2007).

Within the Hauraki and Matamata-Piako Districts, which account for most of the Firth of Thames catchments, dairy cow numbers and stocking rates have changed little over the last five years. In 2012-13 there were 411,000 cows, at 3.01 cows/per effective ha; in 2007-08 there were 409,000 cows, at 3.02 cows/effective ha (LIC and DairyNZ 2008, LIC and DairyNZ 2013).

Riparian fencing and revegetation can be used to reduce sediment and nutrient runoff from the wider catchment. Exclusion of stock from riparian areas and retention or regeneration of riparian vegetation along the Miranda-Pukorokoro coastline will help to protect or improve stream water quality parameters such as temperature, nutrient levels, clarity and sediment loads, and in particular by attenuating flood levels and large pulses of sediment runoff during high intensity rainfall events.

Within the Miranda-Pukorokoro coast catchments about 64 km of stream length (41% of the total 157 km of streams) has forest or scrub vegetation cover. Analysis of aerial photographs indicates that substantial lengths of waterway are also fenced to exclude

stock. Streams with the highest priorities for riparian restoration are the Miranda and Taramaire Streams, as the two major high tide shore bird roosts lie at their mouths.

Waikato Regional Council is now initiating a catchment management programme for the Miranda-Pukorokoro catchment, having not undertaken any rates-targeted work in the past (J. Roxburgh, Waikato Regional Council, pers. comm.).

Overall, improvement of riparian condition within the project area is a fundamental long-term requirement, but is a lower priority than direct protection and enhancement of shorebird habitat.

15. MANAGEMENT UNITS, OPTIONS, AND PRIORITIES

For the purpose of this assessment the Miranda-Pukorokoro coastal area has been divided into 16 management units, totalling 295 ha, based on landforms, hydrosystems, current and potential ecological values, and current and potential management options.

Various management options are outlined in Table 5 for each management unit, as well as the expected beneficial ecological outcomes. Management options are broadly in line with the vision and objectives drawn up by Miranda Naturalists Trust, which have been used as a framework. It is assumed for the Coxhead and Dalton properties landward of East Coast road that, at least in the short-term, restoration options need to allow for the ongoing operation of the properties, or parts of them, for pasture-based farming.

Management units are mapped in Figure 2. Summary information on values, management requirements, and desired beneficial outcomes is set out in Table 5.

Table 6 provides an outline of suggested management priorities, within relevant management units and, broad timeframes. The rate at which management actions can be implemented will depend on the degree of stakeholder agreement, a clear project structure, and availability of funding. Three to five years would be a "best case" timeframe.

Figure 2. Suggested management units for shorebird habitat, estuarine wetland and chenier plain restoration within the Miranda-Pukorokoro coastal area

Table 5: Management Units, management requirements, and potential outcomes for the Miranda-Pukorokoro coast.

MU No.	Management Unit (MU) Name	Tenure	Summary	Management Requirements (Most Important Actions in Bold)	Beneficial Outcomes (Green=Primary, Orange=Secondary)						Potential Costs
					Non-breeding Shorebirds	Breeding Shorebirds Wetland Birds	*Mimulus* Herbfields	Saltmarsh Vegetation	*Ileostylus micranthus*	Chenier Plain Ecosystem	
1	Miranda Stream intertidal flats (15.1 ha)	Crown	Intertidal flats adjacent to the major high tide wader roost on the Firth of Thames and therefore an important foraging area. Hand pulling of mangroves, which would otherwise likely colonise the entire flat, has been carried out by MNT and will need to be sustained indefinitely.	- **Ongoing removal of mangrove seedlings.** - Predator control.							- In-kind/volunteer time.
2	Mangroves and outer shell-bank (17.6 ha)	Finlay QEII Covenant; Crown	Mangroves, saltmarsh. No management necessary other than to minimise human disturbance to roosting shorebirds.	- **Predator control.**							- In-kind/volunteer time.
3	Miranda Stream estuary (12.5 ha)	Crown	Saltmarsh herbfields, ungrazed rough pasture, mangroves.	- Maintain existing fences to exclude stock.							- Minimal
4	Miranda Stream saltmarsh (9.6 ha)	Crown	Part of the intertidal flats adjacent to the major high tide wader roost on the Firth of Thames and therefore an important foraging area. Hand pulling of mangroves, which would otherwise likely colonise the entire flat, has been carried out by MNT and will need to be sustained indefinitely.	- **Mangrove seedling management.** - Predator control.							- In-kind/volunteer time.
5	Finlay QEII covenant (20 ha)	Finlay QEII Covenant	Shallow ponds, saltmarsh herbfields, *Mimulus* herbfield, ungrazed rough pasture, mangroves, chenier landforms. As current, plus grazed short pasture. Graze pasture areas, but exclude stock from ponds.	- **Graze or mow pasture areas.** - Exclude stock from ponds where possible. - **Remove mangrove seedlings.** - Predator control.							- Grazing: nil. - Mowing[1]: est. $2,000/annum - Stock fencing: already in place. - Mangrove seedling control: volunteer time.
6	Dalton-Coxhead: Pukorokoro catchment (79.3 ha)	Private land: Coxhead, Dalton	Seasonally boggy, low producing pasture currently used to graze cattle, seasonally wet shallow ponds. Flap-gates at the mouth of Pukorokoro Stream, and a network of drains and stopbanks is used to minimise flooding and saltwater intrusion. Allow ingress of tidal flows either by periodic opening of flap-gates to let in pre-determined volume of water, or modification with a high level weir. Assess water levels and shorebird behaviour post-works to determine need for and best location of shallow ponds, blade off minor stopbanks and in-fill drains within the stop-banked area, continue periodic grazing to maintain shore bird roosts in short stature vegetation.	- Purchase part/all of properties? - **Trial periodic small-scale flooding by opening flap-gates.** - Monitor results and further develop shorebird roost concept. - Continue periodic grazing for shore bird roost habitat maintenance.							- Purchase whole or part (say east of eastern drain) of properties. - Additional technical investigation of flap-gates, water levels and topography (as per Golder 2014): $ - substantial. - Ongoing grazing of roost site: no cost (undertaken by landowner). - Mowing 10 ha roost site instead of grazing: est. $1,000 per annum. - Produce design, obtain resource consent (if needed), and undertake earthworks to create shallow pond as part of shorebird roost: $ - substantial

[1] Based on estimate of $100/ha/annum http://www.siddc.org.nz/files/focusdayhandout-feb13.pdf

MU No.	Management Unit (MU) Name	Tenure	Summary	Management Requirements (Most Important Actions in Bold)	Beneficial Outcomes (Green=Primary, Orange=Secondary)						Potential Costs
					Non-breeding Shorebirds	Breeding Shorebirds Wetland Birds	*Mimulus* Herbfields	Saltmarsh Vegetation	*Ileostylus micranthus*	Chenier Plain Ecosystem	
7	Dalton-Coxhead: Miranda Stream catchment (17.9 ha)	Private land: Coxhead, Dalton	Seasonally boggy pasture grazed by cattle, patches of saltmarsh, mangroves and intertidal mudflats. Miranda Stream is stop-banked but there are no flap-gates, therefore in some ways it would be simpler to create shorebird roost habitat here than in the Pukorokoro Stream. However, potential roost sites are further from the coast (*c.*1 - 1.3 km) than potential roost sites on Pukorokoro Stream (400-500 m from coast, and directly across road from the Stilt Ponds). Therefore the Miranda Stream should be regarded as a lower-priority for shorebird roost creation than the Pukorokoro Stream.	- Purchase part/all of properties? - **Continue periodic grazing for shore bird roost habitat.**							- Purchase only if part of whole property purchase of Coxhead and Dalton properties. - Grazing: no cost - Mowing 10 ha roost site instead of grazing: est. $1,000 per annum.
8	Pukorokoro Stream fenced section (0.6 ha)	Dalton	Ungrazed saltmarsh herbfield - a good indicator of what other parts of Pukorokoro Stream might return to if ungrazed.	- Maintain existing fences to exclude stock.							- Future fence maintenance or replacement.
9	Dalton coastal (12.1 ha)	Dalton, Crown	Rough pasture, damp swale with saltmarsh herbfield. Chenier landforms.	- Graze pasture if wet areas can be fenced to protect saltmarsh. - Otherwise leave ungrazed. - Potential site for restoration planting (covenant or land purchase required?). - Predator control.							- Restoration planting: *c.*$30,000/ha to achieve canopy closure. - Predator control: volunteer time
10	Access Bay to Taramaire Stream (47.3 ha)	DOC, road reserve.	Taramaire high tide roost. Shallow ponds, saltmarsh herbfields, ungrazed rough pasture, mangroves, planted shrubland (strip next to road). Chenier landforms. Grazing concessions for Miranda Taramaire Wildlife Reserve have expired recently - hence the lack of recent grazing pressure and infestation of rank grass and fennel, and there are questions over economic viability of grazing (S. Benham, DOC, pers. comm.). DOC is looking to renew grazing however. The roadside strip of planted shrubland is part of efforts to increase the size and security of *Ileostylus micranthus* population. Planted shrubs were initially inoculated with *Ileostylus* seed, but since then mistletoes have been germinating naturally on additional host plants.	- Graze pasture if wet areas can be fenced to protect saltmarsh. - Graze or mow adjacent to Taramaire high tide roost. - Otherwise leave ungrazed. - **Potential site for restoration planting, especially to support *Ileostylus* population.** - Predator control.							- Restoration planting: *c.*$30,000/ha to achieve canopy closure. - Predator control: volunteer time - Grazing: no cost - Mowing 10 ha roost site instead of grazing: est. $1,000 per annum.
11	Kaiaua to Taramaire campervan park "Ray's Rest" (18.4 ha)	DOC, recreation reserve.	Taramaire high tide roost. Mown grass strip adjacent to the beach, heavily used by campervans and the community, and the resulting beach activity has degraded its role as a high tide roost. Limited options to restore roosting habitat except by restricting vehicle access and advocacy to minimise human activity on the beach, which the local authority have been undertaking (MNT 2012).	- Mow grass. - **Restrict vehicle access to Taramaire Stream mouth.** - **Restrict human activity along beach at high tides** - **Enforce 'no dogs' bylaw**							- Low
12	MNT Shorebird Centre (1.2 ha)	Private land: MNT	Contains a small lagoon with partially vegetated margins. Site is constrained, size-wise, and limited potential for additional restoration.								- None, other than ongoing maintenance.
13	MNT block bordering Dalton block. (10.3 ha)	Private land: MNT	Farmland purchased by MNT with a view to undertaking shorebird habitat restoration? However, it may not be ideally sited (either hydrologically or distance-wise) for creation of a spring high tide roost).	- Further investigate feasibility for shore bird roost enhancement.							- None.
14	Rangipo Road mangroves and saltmarsh (20.9 ha)	DOC	Mangroves, saltmarsh. No additional management needed other than to maintain any fences to exclude stock.	- None.							- None.

MU No.	Management Unit (MU) Name	Tenure	Summary	Management Requirements (Most Important Actions in Bold)	Beneficial Outcomes (Green=Primary, Orange=Secondary)						Potential Costs
					Non-breeding Shorebirds	Breeding Shorebirds Wetland Birds	*Mimulus* Herbfields	Saltmarsh Vegetation	*Ileostylus micranthus*	Chenier Plain Ecosystem	
15	McCartie NHF bock (4.8 ha)	DOC	Grazed/mown chenier plain, tidal lagoon, significant *Mimulus* population - one of largest along Miranda coast. Longfin eel and inanga present in lagoon. DOC planning to trial planting in winter 2014 of estuarine shrubland vegetation along border of *Mimulus* zone to prevent invasion/replacement by grass sward. Ecoquest writing a management plan for site (S. Benham, DOC, pers. comm.). Limited potential as a high tide shorebird roost given distant from nearest major roost at Taramaire.	- **Trial saltmarsh shrubland planting (stock-fenced) to buffer *Mimulus from pasture growth.*** - Graze/mow unplanted areas.							- Restoration planting: *c.*$30,000 ha to achieve canopy closure. - Grazing concession for unplanted areas: no cost
16	Kaiaua (7.8 ha)	Reserve	A narrow strip of mainly mown grass reserve between road and beach, and including the village of Kaiaua, and the mouth of the Hauarahi Stream. The small spit on the southern side of the stream mouth provides a reasonably secure roost for >100 shorebirds on spring high tides, as long as human disturbance is minimised. The mown grass has little potential for additional shorebird roost enhancement or restoration plantings.	- As current. - Enforce dog bylaws plus advocacy to maintain stream mouth spit as a secure roost.							- None.

Table 6: Management actions, locations, and relative priorities for the Miranda-Pukorokoro coast and related catchments. MU = Management Units - refer to Figure 2 and Table 5.

Action		Location	Phase 1	Phase 2	Phase 3
1	Land purchase.	MU 6 and MU 7.	[1]		
2	Trial flooding of Pukorokoro Stream.	MU 6.			
3	Earthworks to create roost pond; or 4.	MU 6.			
4	Remove Pukorokoro flood control flap-gates.	MU 6.			
5	Remove stopbank between Miranda and Pukorokoro Streams.	MU 6 and MU 7.			
6	Earthworks to create roost ponds.	MUs 6, 10 (Taramaire Stream south bank)?			
7	Grazing or mowing.	MUs 5, 6, 7, 10 (Taramaire Stream south bank), 14.			
8	Mangrove management.	MUs 1, plus 4 (if necessary).	[2]		
9	Predator control	MUs 5, 6.			
10	Restoration planting of woody/ terrestrial saltmarsh vegetation	MU 14 (McCartie, for *Mimulus* buffering); MU 10 (Access Bay; *Ileostylus* hosts).			
11	Fence out stock from saltmarsh	MUs 9, 10 (Access Bay), 7.			
12	Riparian management in Miranda coast catchments	Miranda coast streams			
13	Riparian management in Waihou Piako and Waitakaruru catchments	Waihou Piako and Waitakaruru catchments			

[1] Orange shading = Large, costly or complex actions i.e. requiring some combination of negotiated land purchase/agreement, grazing lease, resource consents, and capital works.

[2] Green shading = Small, ongoing, low-intensity or low-cost actions that are either ongoing, or readily implemented with fewer statutory requirements and costs.

16. CONCLUSIONS

The natural heritage values of the Miranda-Pukorokoro coastline are very high, in relation to shorebirds and their habitats, the wider chenier plain and estuarine landforms and ecosystems and are considered to be nationally important and a very high priority for protection and enhancement.

Various options are available, in various locations and at differing scales, for a range of management responses to protect and enhance habitats. These options include land purchase and formal protection, water level manipulation, excavation of shallow ponds, grazing management, ongoing predator control, ongoing mangrove management, indigenous revegetation, advocacy and regulation, and improved management of wider contributing catchments. The area has been subdivided into management units, and potential management actions and relative priorities have been assigned to each unit. Many potential actions have been identified, and some require further evaluation, such as water level manipulation and grazing management/ mowing.

Restoration management at Miranda-Pukorokoro therefore needs to be well-integrated across all recognised values, especially given that key potential management actions such as grazing and water level management are likely to involve trade-offs in terms of which outcomes can be achieved and which are compromised.

There are multiple stakeholders, land tenures, and interests involved in the Miranda-Pukorokoro area, and successful restoration and protection will require a credible, comprehensive, and well-supported management strategy, and ongoing input by all parties. Formation of a working party whose task is to oversee the development of an agreed plan framework, is a logical next step.

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APPENDIX 1

SITE PHOTOGRAPHS

Plate 1: Recent cattle grazing of rough pasture between the Pukorokoro Stream flap-gate and East Coast Road (Unit 6). Note heavily grazed bases of fennel.

Plate 2: Culverts and flap-gates on the Pukorokoro Stream (Unit 6).

Plate 3: Pukorokoro Stream, drain running east-west just upstream of flap-gates (Unit 6). Miranda Stream is on the other side of the stop-bank at left of photo.

Plate 4: Pukorokoro Stream (Unit 6), steep bank on fenced true left and heavily pugged, shallow, intermittently wet area on true right. Potential shorebird roost and habitat for *Mimulus*?

Plate 5: Coxhead property near Pukorokoro Stream (Unit 6). Stock-grazed and pugged, intermittently wet area. Potentially a site for high tide roost pond.

Plate 6: Dalton property. A *c.*150 m section of the Pukorokoro Stream has been fenced to exclude stock (Unit 8). Rank grassland inside the fence adjoins a healthy glasswort herbfield.

Plate 7: Miranda Stream estuary (Unit 3). Low bunds formed by past drain excavations could be bladed flat to help restore natural water flow patterns and levels.

Plate 8: Saltmarsh vegetation at the mouth of the Miranda Stream (Unit 4). Scattered small mangroves have established in the background.

Plate 9: The Stilt Ponds (Unit 5). Shallow brackish depressions formed by previous shell mining. Standing dead small mangroves reflect vulnerability to changes in water levels and salinity. Note flocks of shorebirds in mid-background.

Plate 10: Shell ridge (Unit 2), adjacent to site of current bird watching hide.

Plate 11: MNT bird watching hide (Unit 2). Scoured-out section of raised path should be replaced by boardwalk to allow unimpeded tidal flows.

Plate 12: Dalton property seaward of East Coast Road (Unit 9.), looking south. The drained depression eventually connects to the stilt ponds.

Plate 13: Fenced pond, Access Bay (Unit 10; Taramaire Reserve). Ungrazed dense tall fennel and exotic pasture, and zones of saltmarsh herbfield, arrow grass, and sea rush on wetter areas.

Plate 14: McCartie NHF block (Unit 15). Stock-grazed lagoon edge with *Mimulus* present.

Plate 15: Taramaire high tide roost, mouth of Taramaire Stream. Well-maintained pasture north of the stream mouth (Unit 11, ‘Ray’s rest’), and rough pasture and saltmarsh south of stream mouth (Unit 10, right foreground), provide spring high tide roost habitat that could potentially enhanced.

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