

LAKE AREARE HABITAT ENHANCEMENT PLAN



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LAKE AREARE HABITAT ENHANCEMENT PLAN



Contract Report No. 3139

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Waikato District Lakes and Wetlands Memorandum of Agreement Group

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1. INTRODUCTION

Lake Areare (33 ha) is located 6 km south-east of Ngaruawahia, and approximately 20 km north of Hamilton. It is the largest of eight peat lakes, associated with the historic Kainui peatlands, which are collectively known as the Horsham Downs Peat Lakes. The lake provides habitat for a range of indigenous plants and animals including eight threatened bird and fish species and good-sized populations of gamebird species.

Lake Areare was identified as a key site for future collaboration by the Waikato District Lakes and Wetlands Memorandum of Agreement Group¹. An Inter-Agency Action Plan for Lake Areare was subsequently compiled. The plan identified current values, threats and opportunities for collaborative management and listed actions to protect, enhance, and restore Lake Areare (Wildland Consultants 2012). A habitat enhancement plan was one of the actions identified. The purpose of this plan is to build on past restoration efforts while increasing diversity of habitat types.

This report comprises the habitat enhancement plan, which contains a description of the site including climate, soils, fauna and current vegetation and habitat types. Target vegetation types for habitat enhancement are identified for Lake Areare. The habitat enhancement area is divided into six management units and recommendations are made for each of these along with suggested timing.

2. GOALS

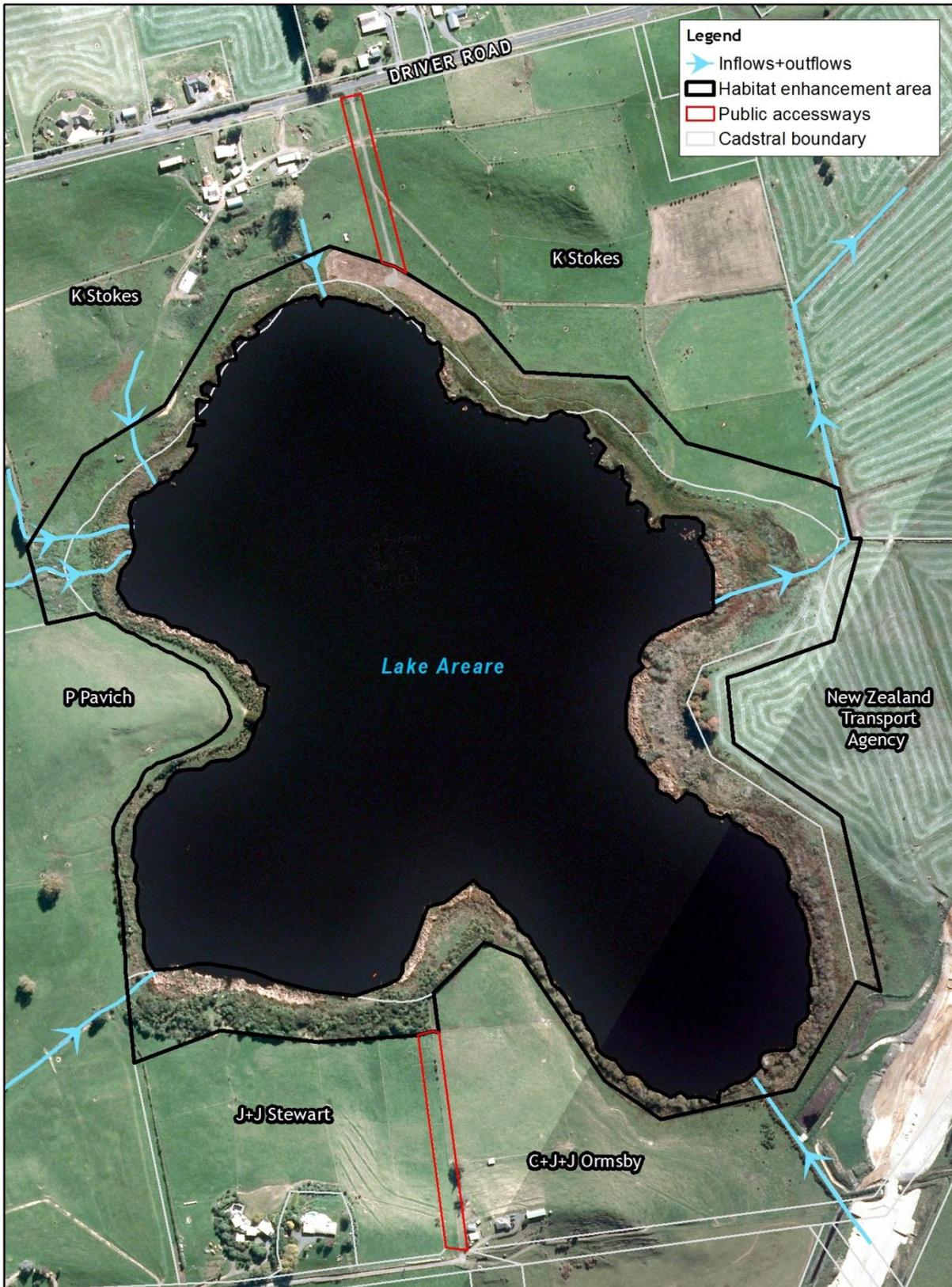
The following goals have been identified for habitat enhancement at Lake Areare (from Wildland Consultants 2012):

- Increase the diversity of indigenous peat lake habitat types at Lake Areare for plants and animals.
- Enhance existing areas of revegetation by supplementing with a greater diversity of indigenous species.
- Restore kuta (*Eleocharis sphacelata*) beds to provide habitat for threatened bird species.
- Establish rare peatland plant communities.
- Establish a full sequence of indigenous ecosystem types from lake to lowland dryland forest.

3. SITE DESCRIPTION

The area covered by this plan is shown in Figure 1. It includes all of the land within the Lake Areare Wildlife Management Reserve, road reserves that buffer the lake, and a 20 m marginal strip land that is currently owned by New Zealand Transport Authority (NZTA) but which is intended to be transferred to the Department of Conservation. These reserves collectively provide a land buffer around the lake which ranges in width from 15 m to 200 m.

¹ This group includes Auckland Waikato Fish and Game Council, Department of Conservation, Waikato District Council, Waikato Regional Council and Waikato-Tainui.



Data Acknowledgment
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Figure 1: Habitat enhancement area at Lake Areare

0 100 200 m

Wildlands © 2009
 www.wildlands.co.nz, 0508 WILDNZ

Scale: 1:5,000
 Date: 16/07/2013
 Cartographer: FM
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The surrounding catchment (268.2 ha) is used for dairy and beef farming, and also contains lifestyle blocks.

There are two unformed road reserves that provide public access to the lake from Driver Road (vehicle and foot access) and Ormsby Road (foot access only). The Waikato Expressway (i.e. the realignment of SH1 between Taupiri and Horotiu) comes within 100 m of the south-eastern corner of Lake Areare. NZTA have recently developed both a constructed wetland and a metalled vehicle track. The latter is from the end of the formed section of Ormsby Road and is designed to enable public (walking) access to the constructed wetland and DOC administered land adjoining the Waikato Expressway.

3.1 Climate

Lake Areare occurs within the Hamilton Ecological District which is characterised by warm humid summers with heavy frosts in winter and little wind. Rainfall ranges from 1,100-1,400 mm p.a. with maximum rainfall usually occurring during winter (McEwen 1987).

3.2 Soils

Peat soils (>1 m depth) are predominant on the flats on the eastern and southern sides of the lake. Loams and peaty loams dominate the western and northern sides of the lake (<http://smap.landcareresearch.co.nz/smap#home>, accessed 30/9/12).

3.3 Hydrology

The lake has four natural inflows and a drain on the western side (Figure 1). An artificial drain on the south-eastern side drains c.140 ha of peat that has been converted to pasture to the east and south of the lake. Originally the lake would have had no outlet however a drain has been constructed on the north-eastern margin of the lake which discharges to the Waikeri Stream near Hopuhopu and then to the Waikato River.

Waikato Regional Council installed a weir on the lake outlet in 2005, to raise minimum summer water levels. The weir started to fail after two years and a new weir was built c.0.5 m downstream in 2008. Maximum depth of the lake is 5.1 m (Fergie 2003) and water levels now fluctuate up to 0.8 m (Figure 2). Water levels reach their maximum in winter months (c.23.1 m asl) and their minimum during summer (c.22.45 m asl). The topography of land around the lake indicates that the lake was probably larger in the past.

Waikato Regional Council has monitored lake levels at Lake Areare but will cease monitoring now that the resource consent conditions for monitoring have been met.

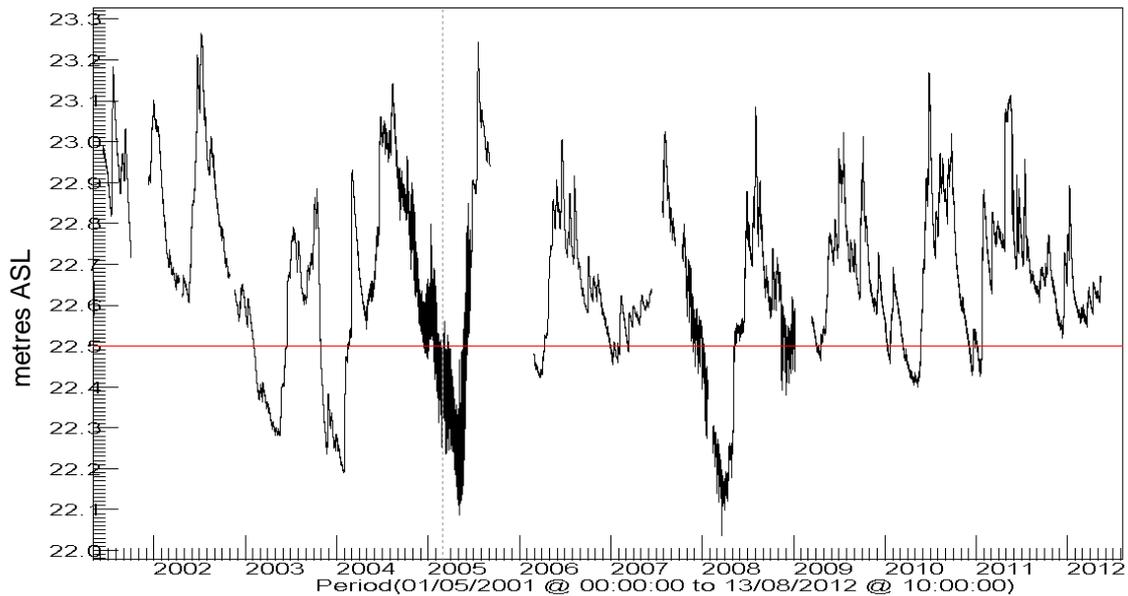


Figure 2: Time series plot of water levels at Lake Areare between 1/5/02 and 13/8/12. The weir was established on the outflow in April 2005 however, erosion and leakage occurred around the weir, so a wider weir was built c.0.5 m downstream in May 2008. Since then minimum water levels have rarely fallen below the target minimum water level of 22.5 m ASL (red line).

3.4 Water quality

Water quality was surveyed at Lake Areare in December 2010, February 2011, and May 2011 by WRC. Results (Table 1) indicate that the lake is hypertrophic with poor water clarity. This is consistent with the recent occurrence of algal blooms observed by lake users.

Table 1: Water quality at Lake Areare. Source: Waikato Regional Council.

Water Quality Measure	Value	Water Quality Guidelines
Mean secchi (m)	0.48	> 1.6 m for human recreational use ¹
Ph	6.63	4.6- 5.5 for a pristine peat lake ²
Turbidity (NTU)	18.7	< 5 NTU for plant growth ¹
Mean Chl a (mg/m3)	45	
Mean TN (mg/m3)	2,500	< 500 to prevent nuisance plant growth ¹
Mean TP (mg/m3)	150	< 40 to prevent nuisance plant growth ¹
Trophic Level Index	6.35	> 6 = hypertrophic ³

¹ Tulagi 2011.

² Waipa District Council 2007.

³ Burns *et al.* 1999.

Constructed wetlands are planned for all of the lake inflows to reduce sediment and nutrient inputs to the lake. NZTA will complete a constructed wetland on the main inflow in 2013 that will capture sediment and other contaminants from surrounding farm run-off during normal flows and less than five-year flood events. The constructed wetland is based on the Auckland Regional Council's TP10 guidelines (Auckland Regional Council 2003) however the size of the wetland (0.56% of the

catchment) is below the 1-2.5% recommended by McKergow *et al.* (2007) for substantially reducing nutrient and sediment loads from pastoral catchments.

Funding has been granted by the Waikato River Clean-Up Trust to design and construct wetlands on all other inflows by 2015. The size of constructed wetlands on these inflows will be based on 2.5% of catchment size and will include a distributed discharge through lakeside riparian vegetation to maximise the potential for uptake of dissolved phosphorus and remaining dissolved nitrogen exiting the system.

Waikato Regional Council have undertaken to repeat lake water quality monitoring at Lake Areare at a minimum of three-yearly intervals to determine whether there have been improvements in water quality as a result of initiatives implemented from funding granted by the Waikato River Clean-Up Trust.

3.5 Fauna

Fish species that have been recorded at Lake Areare by DOC staff and Fergie (2003) are listed in Table 2. It is likely that other fish species are present in the lake including the threatened black mudfish (*Neochanna diversus*), and an indigenous bully, *Gobiomorphus cotidianus*. The pest fish, koi carp (*Cyprinus carpio*) has never been observed in Lake Areare but the possibility that it is present cannot be discounted. Recent surveys of the outlet drain and stream to the Waikato River indicated there are no obvious fish barriers with koi remains found in the lower 100 m of the stream (G Tempero, University of Waikato Report for DOC 2013; pers comm A Daniels to DOC 2013).

Table 2: Fish species recorded at Lake Areare.

Common Name	Scientific Name	Threat Classification ¹
Short-finned eel	<i>Anguilla australis</i>	
Long-finned eel	<i>Anguilla dieffenbachia</i>	At Risk -Declining
Goldfish*	<i>Carassius auratus</i>	
Mosquito fish*	<i>Gambusia affinis</i>	
Rudd*	<i>Scardinius erythrophthalmus</i>	
Catfish*	<i>Ictalurus nebulosus</i>	

¹ Threat classification as listed in Allibone *et al.* (2010). *Introduced species.

Avifauna that have been recorded at Lake Areare are listed in Table 3 and include birds seen during a six hour site visit by Wildland Consultants on 10 April 2013. Spotless crake (*Porzana tabuensis plumea*) and North Island fernbird (*Bowdleria punctata vealeae*) calls were played at two locations, but no response from these species were detected despite the occurrence of suitable habitats.

3.6 Flora

One hundred and four plant species were recorded at Lake Areare during a walk-through inspection on 10 April 2013 (Appendix 1). Fifty indigenous species, including thirteen planted species were present, and 54 exotic species. No threatened species (de Lange *et al.* 2009) were observed.

Table 3: Bird species recorded at Lake Areare.

Common Name	Scientific Name	Threat Classification ¹	Abundance on 12 April 2013
Australasian bittern	<i>Botaurus poiciloptilus</i>	Threatened-Nationally Endangered	Not observed.
Australasian shoveler	<i>Anas rhynchos</i>		Not observed.
Australian magpie*	<i>Gymnorhina tibicen</i>		Heard in neighbouring pasture.
Banded rail	<i>Gallirallus philippensis assimilis</i>	At Risk-Naturally Uncommon	Not observed.
Black shag	<i>Phalacrocorax carbo novaehollandiae</i>	At Risk-Naturally Uncommon	One bird seen.
Black swan	<i>Cygnus atratus</i>		Eight birds recorded.
Blackbird*	<i>Turdus merula merula</i>		Common on margins.
Canada goose*	<i>Branta canadensis maxima</i>		c.60 birds recorded.
Common pheasant*	<i>Phasianus colchicus</i>		Not observed.
Grey duck	<i>Anas superciliosa</i>	Threatened-Nationally Critical	Not observed.
Grey teal	<i>Anas gracilis</i>		Not observed.
Grey warbler	<i>Gerygone igata</i>		Regularly heard on lake margins.
New Zealand kingfisher	<i>Todiramphus sanctus vagans</i>		Common in wetland habitat on lake margins.
Little black shag	<i>Phalacrocorax sulcirostris</i>	At Risk-Naturally Uncommon	Two birds seen.
Little egret	<i>Egretta garzetta immaculata</i>		Not observed.
Mallard*	<i>Anas platyrhynchos platyrhynchos</i>		c.15 birds recorded.
North Island fantail	<i>Rhipidura fuliginosa placabilis</i>		Common on lake margins.
NZ dabchick	<i>Poliiocephalus rufopectus</i>	Threatened-Nationally Vulnerable	Not observed.
Paradise shelduck	<i>Tadorna variegata</i>		c.150 birds recorded.
Pukeko	<i>Porphyrio melanotus melanotus</i>		Common on lake margins.
Royal spoonbill	<i>Platalea regia</i>	At Risk-Naturally Uncommon	Not observed.
Silvereye, tauhou	<i>Zosterops lateralis lateralis</i>		Common on lake margins.
Skylark*	<i>Alauda arvensis</i>		Common in surrounding pasture habitat.
Spur-winged plover	<i>Vanellus miles novaehollandiae</i>		Common on lake margins and in surrounding pasture.
Swamp harrier	<i>Circus approximans</i>		Occasional bird seen flying over site.
Welcome swallow	<i>Hirundo neoxena neoxena</i>		Common feeding over lake habitat and margins.
White heron	<i>Ardea modesta</i>	Threatened-Nationally Critical	Not observed.

¹ Threat classification as listed in Miskelly *et al.* (2008).

* Introduced species.

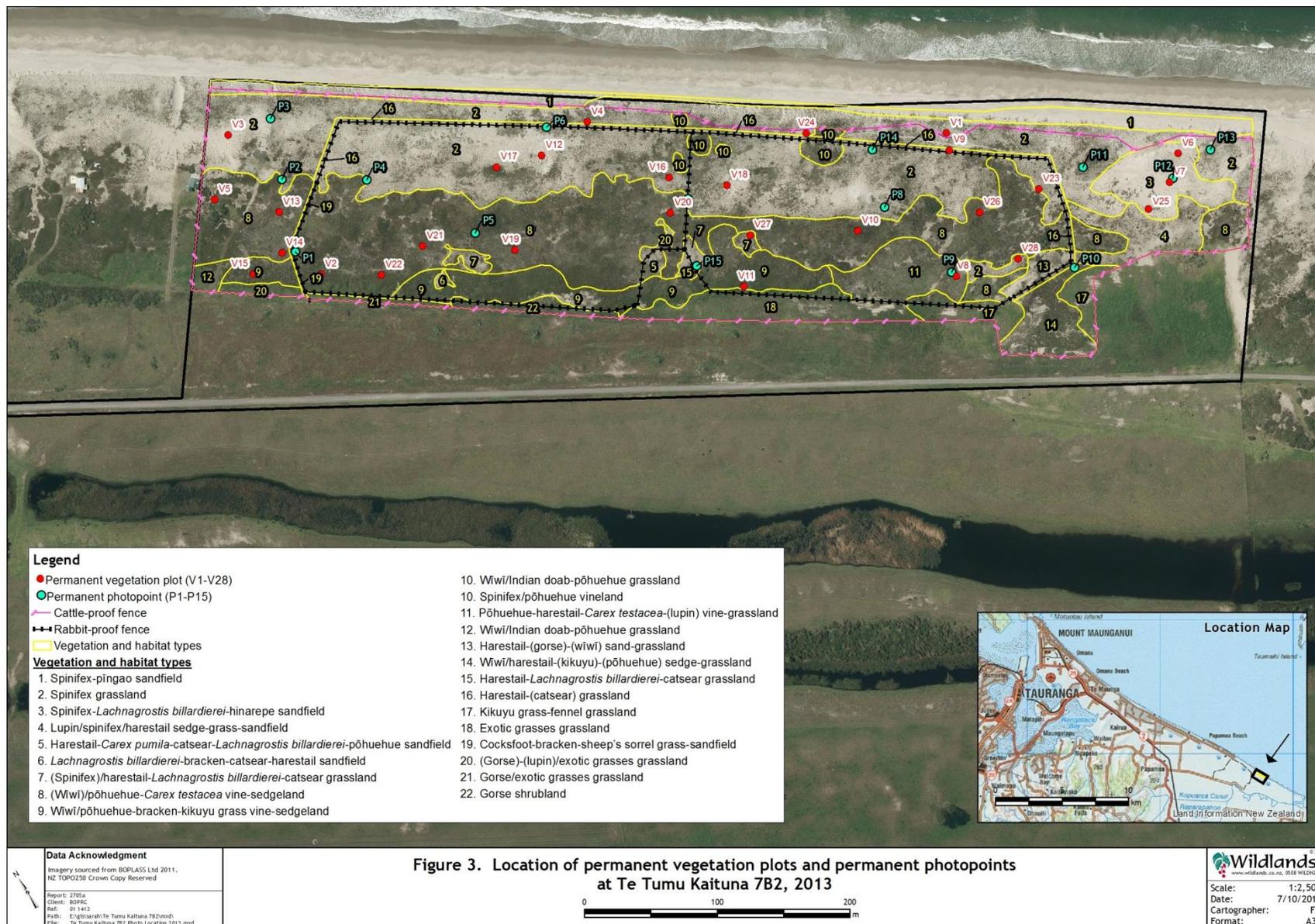
3.7 Vegetation and habitats

Fifteen broad vegetation and habitat types were described within the habitat enhancement area during a site visit on 10 April 2013 (listed in Table 4 and mapped in Figure 3).

Table 4: List of vegetation and habitat types and area (hectares) within the habitat enhancement area.

Vegetation and Habitat Type No.	Area (ha)	Description
1	c.1.3	<p>Raupo reedland</p> <p>Raupo (<i>Typha orientalis</i>) occurs on the lake margins where it sometimes forms monospecific stands up to 10 m wide. It is occasionally fringed on the lakeward margin by kuta (<i>Eleocharis sphacelata</i>). Where it occurs at very shallow depths it is often found in association with <i>Carex secta</i>, <i>Carex virgata</i>, <i>Myriophyllum propinquum</i>, <i>Isachne globosa</i>, Mercer grass (<i>Paspalum distichum</i>), primrose willow (<i>Ludwigia peploides</i> subsp. <i>montevidensis</i>), water purslane (<i>Ludwigia palustris</i>), and swamp willow weed (<i>Persicaria decipiens</i>).</p>
2	c.3.6	<p>Mixed indigenous-exotic rushland and grassland</p> <p>A highly variable vegetation type located on the wet margins of the lake. Components include:</p> <ul style="list-style-type: none"> • Rank exotic grassland dominated by Yorkshire fog (<i>Holcus lanatus</i>) with common beggars' tick (<i>Bidens frondosa</i>), sea aster (<i>Aster subulatus</i>), water purslane, Mercer grass and <i>Juncus tenuis</i>; • Swamp willow weed-(soft rush)-(<i>Juncus edgariae</i>)/water purslane-primrose willow herbfield; • (Grey willow)/<i>Carex maorica</i>-(<i>Carex secta</i>)/primrose willow-water purslane-swamp willow weed sedgeland; • Soft rush (<i>Juncus effusus</i>)-<i>Juncus australis</i>-beggars' tick-sea aster-swamp willow weed/ Mercer grass-primrose willow rushland; • Manuka (<i>Leptospermum scoparium</i>)-harekeke (<i>Phormium tenax</i>)-(ti kouka - <i>Cordyline australis</i>)-(karamu - <i>Coprosma robusta</i>)-beggars' tick-Mercer grass-primrose willow shrubland; and • Patches of <i>Machaerina rubiginosa</i> sedgeland.
3	<0.1	<p><i>Machaerina rubiginosa</i> sedgeland</p> <p>An indigenous vegetation type located on the eastern side of the lake. This vegetation types comprises a dense sward of <i>Machaerina rubiginosa</i> with few other species present.</p>
4	c.1.5	<p>Recent plantings</p> <p>A mixture of species (generally between 0.5 m and 2.0 m tall) including karamu, cabbage tree, manuka, harakeke, totara (<i>Podocarpus totara</i>), <i>Carex virgata</i>, <i>Carex secta</i>, swamp coprosma (<i>Coprosma tenuicaulis</i>), and occasional kahikatea (<i>Dacrydium dacrydioides</i>).</p> <p>Rank grassland is present between plantings including Yorkshire fog, lotus (<i>Lotus pedunculatus</i>), soft rush Scotch thistle (<i>Cirsium vulgare</i>), Australian fireweed (<i>Senecio bipinnatisectus</i>), creeping buttercup (<i>Ranunculus repens</i>), and beggars' tick. Swamp willow weed, primrose willow, water purslane and the indigenous water milfoil, <i>Myriophyllum propinquum</i>, become more common in wet areas closer to the lake edge.</p>
5	c.0.3	<p>Manuka-cabbage tree/harakeke-karamu shrubland (planted)</p> <p>Planted manuka and cabbage trees to 3-4 m tall with an understory of</p>

Vegetation and Habitat Type No.	Area (ha)	Description
		planted harakeke and karamu. Plantings are estimated to be 6-8 years old. Mercer grass and beggars tick dominate the ground cover.
6	c.1.4	(Cabbage tree)-manuka scrub (planted) Planted manuka to 5 m tall with scattered cabbage trees (planted). Harakeke (planted) common on lake side of vegetation type. Occasional kohuhu (<i>Pittosporum tenuifolium</i> - planted), kahikatea (planted), kowhai (<i>Sophora microphylla</i> , planted), mahoe (planted), and ponga (<i>Cyathea dealbata</i>) and mamaku (<i>Cyathea medullaris</i>). In the understorey indigenous ferns are common including water fern (<i>Histiopteris incisa</i>), <i>Hypolepis ambigua</i> and <i>Pteris tremula</i> which appear to have established naturally. These are the most mature plantings at Lake Areare and are estimated to be between 10-12 years old.
7	c.0.1	Harakeke/beggars tick-Mercer grass-creeping bent flaxland (planted) Planted harakeke up to 3 m tall with beggars tick, creeping bent and Mercer grass on the margins.
8	c.0.9	Grey willow-crack willow forest Grey willow (<i>Salix cinerea</i>) and crack willow (<i>Salix fragilis</i>) up to 6 m tall dominate the canopy with occasional weeping willow (<i>Salix babylonica</i>). Raupo is common on margins. Understorey is variable with Mercer grass and primrose willow the most common species. Blackberry is common and dense beneath grey willow on the southern edges of the lake.
9	c.0.1	Oak forest A small cluster of tall oak (<i>Quercus robur</i>) is present on the eastern side of the lake. The trees were planted by gamebird hunters approximately 60 years ago. Gorse is common beneath the oak.
10	<0.1	Gorse scrub Dense stands of 1.5- 2 m tall gorse (<i>Ulex europaeus</i>) were present on either side of the oak forest.
11	c.0.1	Blackberry scrub Blackberry (<i>Rubus fruticosus</i> agg.), 1-2 m tall was present along the margins of the south-eastern lake inflow. Localised gorse was present on the margins.
12	<0.1	Pampas tussockland Small areas of pampas (<i>Cortaderia selloana</i>) and individual pampas were scattered on the eastern side of the lake, close to the oak forest.
13	c.2.9	Pasture (grazed) Pasture within the reserve boundaries has been fenced off and is grazed by stock.
14	c.0.2	Rank exotic grassland (not grazed) This vegetation type was dominated by Yorkshire fog and <i>Paspalum distichum</i> . Other common species include blackberry, inkweed (<i>Phytolacca octandra</i>), Scotch thistle, Australian fireweed, creeping bent (<i>Agrostis stolonifera</i>), beggars' tick', fumitory (<i>Fumaria muralis</i>), and occasional Jerusalem cherry (<i>Solanum pseudocapsicum</i>).
15	<0.1	Bare ground Recently cleared drain for roading development. Scattered recently sprouted exotic grasses.



4. TARGET HABITAT TYPES

The habitat enhancement goals at Lake Areare (Section 1.1) are aimed at establishing plant communities similar to those that would have once occurred at Lake Areare. The oldest surveys of plant communities at Lake Areare are relatively recent having been undertaken in January 1990 and November 1991 (Champion *et al.* 1993). By this time most of the lake margin had been reduced to a narrow band impacted by drainage, stock grazing, nutrient enrichment and weed invasion. There are however a few remnants of indigenous plant communities that provide some guidance on what would have occurred at the lake. Clarkson *et al.* (2007) also provides useful guidance on target habitat types including species lists for peat lakes in the Hamilton Ecological District. Using these sources, habitat enhancement goals and site information contained in the previous section, the following six target habitat types have been identified for Lake Areare:

Lake margin

1. Kuta reedland
2. Raupo reedland
3. Carex sedgeland

Wetland adjacent to lake margin

4. Shrub sedgeland
5. Restiad rushland

Terrestrial margin (occasionally flooded)

6. Kahikatea forest

In determining target habitat types, consideration has been given to whether they can potentially survive the current physical conditions (e.g. high fertility, water fluctuation up to 0.8 m) and whether they can be sustained in the long-term with minimal management. The majority of target habitat types should fulfil these criteria however low fertility vegetation types may be more difficult to establish (e.g. kuta reedland, restiad rushland).

A brief description of target habitat types is provided in the following sections and mapped in Figure 3.

4.1 Kuta reedland

Kuta is an emergent reed that was once abundant at Lake Areare where it formed monospecific stands that occupied 56% of the lake margin, growing from the shore to depths of 2 m and up to 5 m across (Champion *et al.* 1993). Kuta typically dominates deepwater margins providing a source of food, shelter, and protection for invertebrates, birds, and fish (Sorrel and Tanner 1999). Māori have traditionally used kuta for clothing and warm coverings within whare (houses) due to its' soft fibre and thermal qualities (Kapa and Clarkson 2009).

Kuta is currently confined to sparse stands on the western and southern sides of the lake and has been displaced by raupo and floating sudds of primrose willow and swamp willow weed in many locations. Expanding the extent of kuta reedland at Lake

Areare is a specific goal of the habitat enhancement plan although it is not known whether it will flourish in the current nutrient rich environment.

4.2 Raupo reedland

Raupo is an emergent plant that favours fertile waters and may displace other emergent plants when lake waters become enriched¹. In the early 1990s it occupied 34% of the shoreline at Lake Areare where it grew to depths of 1.5 m (Champion *et al.* 1993). It often forms monospecific stands, but is also found growing at peat lakes with other indigenous plant species including kuta, *Machaerina articulata*, burr reed (*Sparganium subglobosum*), *Isolepis prolifera*, *Hydrocotyle pterocarpa*, swamp millet (*Isachne globosa*), sharp spike sedge (*Eleocharis acuta*) and *Myriophyllum propinquum*. It provides valuable habitat for eels and other native fish, waterfowl and some uncommon or rare indigenous birds such as fernbird, spotless and marsh crakes, and bittern. Māori have traditionally used raupo for covering and filling poi, creating canoe sails and temporary rafts, and the starchy rhizomes were an important food source².

Raupo reedland currently occupies 1.3 ha along the lake shoreline at Lake Areare. It currently occupies habitat where kuta previously occurred presenting a potential conflict between retaining this vegetation type and re-establishing kuta.

4.3 *Carex* sedgeland

Pure stands of *Carex secta* naturally occur on lake margins at some peat lakes in the Hamilton Ecological District (Champion *et al.* 1993). *Carex secta* provides excellent shelter and nesting for ground birds such as rails, crakes and waterfowl. When planted on lake margins, its overhanging leaves provide shelter for indigenous fish species such as eels and bullies and aquatic invertebrates such as damselflies.

There are currently small pockets of *Carex* sedgeland dominated by a mix of *Carex secta* and *Carex virgata* on the lake margins at Lake Areare. These species appear to have regenerated following stock exclusion and removal of willow from the lake margin. Both *Carex* species have been planted on the lake margin and within wet hollows as part of the Living Legends planting project (Mike Paviour, Department of Conservation, pers. comm.).

4.4 Shrub sedgeland

Mosaics and mixtures of shrubland and sedgeland were once common around peat lakes in the Hamilton Ecological District on poorly drained peat soils with peat depths >1.0 m (Clarkson *et al.* 2007). The main shrub species included manuka, ti kouka, swamp coprosma, and harakeke, while the main sedge species were *Machaerina teretifolia*, *M. rubiginosa*, *Carex secta*, and *C. virgata*.

¹ <http://www.landcareresearch.co.nz/science/plants-animals-fungi/plants/ethnobotany/weaving-plants/information-sheets/raupo>, accessed 30/4/2013.

² Ibid.

Very few elements of this vegetation type currently occur at Lake Areare. Localised *M. rubiginosa* is still present and manuka is regenerating from the seedbank on the deeper peat soils on the eastern side of the lake since stock exclusion.

4.5 *Restiad* rushland

The historic Kainui peatlands most likely contained the restiad (jointed rush) species *Empodisma robustum* and *Sporadanthus ferrugineus* (Peters 2006). There are no remnants remaining at the Horsham Downs Peat Lakes however recent planting trials to re-establish these species at Lake Komakorau (c.4 km southeast of Lake Areare) were successful.

These jointed ‘rushes’ occur on deep peat soils (>1 m) with the water table close to the surface for most of the year. Associated species include *Machaerina teretifolia*, *Epacris pauciflora*, *Gleichenia dicarpa*, manuka (stunted), *Schoenus brevifolius*, and *Sphagnum cristatum*.

The most suitable sites for establishing this vegetation type are on the eastern side of the lake (south of the outflow) where peat soils are likely to be deepest.

4.6 Kahikatea forest

A tall many layered forest dominated by kahikatea would have occurred on mineralised soils at the foot of low hills in the Hamilton Ecological District (Department of Conservation 2013). Other tall trees species would have included pukatea (*Laurelia novae-zelandiae*), matai (*Prumnopitys taxifolia*) and pokaka (*Elaeocarpus hookerianus*) with an understory of shrubs, ferns, sedges and herbs. In poorly drained soils understory species would have included cabbage tree, *Coprosma rigida*, *C. rotundifolia*, *Machaerina tenax*, *Gahnia xanthocarpa* and *Astelia grandis*. On better drained soils understory species would have included putaputaweta (*Carpodetus serratus*), kaikomako (*Pennantia corymbosa*), turepo (*Streblus heterophyllus*), mapou (*Myrsine australis*), mahoe (*Meliccytus ramiflorus*), wheki (*Dicksonia squarrosa*), and supplejack (*Ripogonum scandens*).

No intact remnants of this vegetation type remain in the Hamilton Ecological District (Clarkson *et al.* 2007). At Lake Areare this vegetation type would most likely have occurred at the base of the hillslopes on the western side of the lake.

5. REVEGETATION STRATEGIES

Lake Areare contains a mix of areas that have been progressively revegetated since c.2000 and areas where no revegetation has occurred. These require different planting strategies. In areas that haven’t been replanted site preparation to remove key weed species is required followed by planting with species tolerant of open sites with enhancement planting occurring in 5-10 years time. In areas that have been replanted or still retain some indigenous vegetation then revegetation should focus on increasing the diversity of species (i.e. enhancement planting) and can include species that prefer sheltered conditions.

Table 5 lists species suitable for each target habitat type depending on whether the site is currently ‘open’ or requires enhancement planting.

Table 5: Revegetation species for target habitat types.

Target Habitat Type	Open Site	Enhancement Planting
Raupo reedland	N/A	<i>Eleocharis sphacelata</i> <i>Isachne globosa</i> <i>Machaerina articulata</i> <i>Sparganium subglobosum</i>
Carex sedgeland	<i>Carex secta</i> <i>Carex virgata</i>	<i>Carex secta</i> <i>Carex virgata</i>
Shrub sedgeland	<i>Blechnum minus</i> <i>Carex secta</i> <i>Carex virgata</i> <i>Coprosma propinqua</i> <i>Coprosma tenuicaulis</i> <i>Cordyline australis</i> <i>Leptospermum scoparium</i> <i>Machaerina rubiginosa</i> <i>Machaerina teretifolia</i> <i>Macherina arthropophylla</i> <i>Phormium tenax</i>	<i>Blechnum minus</i> <i>Machaerina rubiginosa</i> <i>Machaerina teretifolia</i> <i>Macherina arthropophylla*</i>
Restiad rushland	<i>Empodisma robustum</i> <i>Sporadanthus ferrugineus</i>	<i>Epacris pauciflorus</i> <i>Gleichenia dicarpa</i> <i>Machaerina teretifolia</i> <i>Schoenus brevifolius</i>
Kahikatea forest	<i>Carpodetus serratus</i> <i>Coprosma rigida</i> <i>Coprosma robusta</i> <i>Coprosma rotundifolia</i> <i>Cordyline australis</i> <i>Dacrycarpus dacrydioides</i> <i>Leptospermum scoparium</i> <i>Melicytus ramiflorus</i> <i>Myrsine australis</i> <i>Pennantia corymbosa</i> <i>Prumnopitys taxifolia</i> <i>Streblus heterophyllus</i>	<i>Astelia grandis</i> <i>Carpodetus serratus</i> <i>Coprosma rigida</i> <i>Coprosma rotundifolia</i> <i>Dacrycarpus dacrydioides*</i> <i>Freycinetia banksii</i> <i>Gahnia xanthocarpa</i> <i>Parsonsia heterophylla</i> <i>Pennantia corymbosa</i> <i>Streblus heterophyllus</i>

To minimise weed control it is important to try and plant densely enough so that full canopy cover is achieved within 2-3 years. This requires planting at densities between 10,000-40,000 plants per hectare depending on the mix of plant types used (see Table 6 for planting spaces for individual species). In open ground sedges should be planted close together in clusters wherever possible to mimic natural patterns. Canopy trees will be planted much wider apart but with sedges and smaller trees and shrubs in between. Enhancement plantings in areas with established cover can be much wider apart covering as little as 10% of the total area. There are a number of small ground cover plants and ferns already present at Lake Areare which will enhance target habitat types and reduce the need to plant at high densities at some places. These include *Lobelia anceps*, *Lobelia angulata*, *Myriophyllum propinquum*, sharp spike sedge, *Hydrocotyle pterocarpa* and *Centella uniiflora* in the shrub sedgeland habitat type and the ferns *Hypolepis ambigua*, *Histiopteris incisa*, wheki, *Pteris tremula*, ponga, and mamaku which will enhance any understorey plantings beneath the kahikatea forest habitat type.

Recommended species for each target habitat type need to be planted at different densities in order to create a more natural ecosystem. They are also likely to do better if their habitat preferences are taken into account when determining where to locate species on restoration landforms (Table 6).

Table 6: Planting densities and environmental tolerances of revegetation species.

Plant Species	Maximum Height (m)	Plant Spacings	Number per 100m ² OG = Open Ground EC= Established Cover	Plant Tolerances
<i>Astelia grandis</i> swamp astelia	1	1	EC = 10	<ul style="list-style-type: none"> Wet and moist ground Full shade
<i>Blechnum minus</i> swamp kiokio	1.5	1	OG = 20 EC = 10	<ul style="list-style-type: none"> Wet and moist ground Full shade or full sun
<i>Carex secta</i> purei	1.5	1	OG = 100	<ul style="list-style-type: none"> Wet ground Full sun Flooding
<i>Carex virgata</i> purei	1.5	1	OG = 100 EC = 10	<ul style="list-style-type: none"> Wet ground Full sun/semi-shade Flooding
<i>Carpodetus serratus</i> putaputaweta	10	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Damp soil Full shade or full sun Avoid flooding
<i>Coprosma propinqua</i> mingimingi	7	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Wet ground Full sun / semi-shade
<i>Coprosma rigida</i>	5	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Wet or moist ground Full shade or full sun Flooding
<i>Coprosma robusta</i> Karamu	5	1.5	OG = 60 EC = 10	<ul style="list-style-type: none"> Moist ground Full sun Flooding
<i>Coprosma rotundifolia</i>	4	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Wet or moist ground Full shade or full sun Flooding
<i>Coprosma tenuicaulis</i> hukihuki	3	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Wet ground Full sun/semi-shade
<i>Cordyline australis</i> ti kouka; cabbage tree	12	1.5	OG = 60 EC = 10	<ul style="list-style-type: none"> Wet and moist ground Full sun Flooding
<i>Dacrycarpus dacrydioides</i> kahikatea	60	10	OG = 10	<ul style="list-style-type: none"> Moist ground Full sun Flooding
<i>Eleocharis sphacelata</i> kuta	3	0.5	OG = 200	<ul style="list-style-type: none"> Shallow water Full sun
<i>Empodisma robustum</i> wire rush	2	0.5	OG = 200	<ul style="list-style-type: none"> Wet peat Full sun Avoid flooding
<i>Epacris pauciflorus</i>	2	1.5	OG = 10	<ul style="list-style-type: none"> Wet peat Full sun Avoid flooding
<i>Freycinetia banksii</i> kiekie	climber		EC = 10	<ul style="list-style-type: none"> Moist ground Full shade
<i>Gahnia xanthocarpa</i> Giant sedge	1.5	1.5	EC = 10	<ul style="list-style-type: none"> Wet ground Full shade or full sun Flooding
<i>Gleichenia dicarpa</i> umbrella fern	1.5	1	OG = 20	<ul style="list-style-type: none"> Wet peat Full sun Avoid flooding
<i>Isachne globosa</i> swamp millet grass	1	0.5	OG = 100	<ul style="list-style-type: none"> Wet ground Full sun Flooding

Plant Species	Maximum Height (m)	Plant Spacings	Number per 100m ² OG = Open Ground EC= Established Cover	Plant Tolerances
<i>Leptospermum scoparium</i> manuka	8	1.5	OG = 60 EC = 10	<ul style="list-style-type: none"> Wet and moist ground Full sun
<i>Macherina arthrophylla</i>	2	1	OG = 100	<ul style="list-style-type: none"> Wet and moist ground Full sun
<i>Machaerina articulata</i>	2	1	OG = 100	<ul style="list-style-type: none"> Shallow water Full sun
<i>Machaerina rubiginosa</i>	2	1	OG = 100	<ul style="list-style-type: none"> Wet and moist ground Full sun
<i>Machaerina teretifolia</i>	2	1	OG = 100	<ul style="list-style-type: none"> Wet peat Full sun Avoid flooding
<i>Melicytus ramiflorus</i> mahoe	10	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Moist and dry ground Full sun or full shade
<i>Myrsine australis</i> mapou	7	1.5	OG = 20 EC = 10	<ul style="list-style-type: none"> Moist and dry ground Full sun or full shade
<i>Parsonsia heterophylla</i> NZ passionfruit	climber		EC = 10	<ul style="list-style-type: none"> Moist ground Full sun or semi-shade
<i>Pennantia corymbosa</i> kaikomako	12	1.5	EC = 10	<ul style="list-style-type: none"> Moist ground Full sun or semi-shade Sheltered site
<i>Phormium tenax</i> harakeke	3	1.5	OG = 60 EC = 10	<ul style="list-style-type: none"> Wet and moist ground Full sun and semi-shade
<i>Prumnopitys taxifolia</i> matai	35	10	OG = 10 EC = 15	<ul style="list-style-type: none"> Moist and dry ground Full sun or full shade Flooding
<i>Schoenus brevifolius</i>	2	0.5	OG = 100	<ul style="list-style-type: none"> Wet peat Full sun Avoid flooding
<i>Sparganium subglobosum</i> burr reed	1	1	OG = 20	<ul style="list-style-type: none"> Wet and moist ground Full sun and semi-shade
<i>Sporadanthus ferrugineus</i> giant cane rush	3	0.5	OG = 200	<ul style="list-style-type: none"> Wet peat Full sun Avoid flooding
<i>Streblus heterophyllus</i> turepo	12	1.5	EC = 10	<ul style="list-style-type: none"> Moist ground Full sun or semi-shade Sheltered site

6. MANAGEMENT UNITS

The project area has been divided into six management units (Table 7, Figure 4), with recommendations for each unit identified.

Table 7: Management units at Lake Areare.

Management Units	Area (ha)
A: Living Legends Plantings	4.03
B: Eastern margin	3.54
C: Grey willow forest	1.23
D: Ti kouka-manuka scrub	2.44
E: Mixed plantings	1.14
F: Western margin	2.50

6.1 Management Unit A: Living legend plantings

Lake Areare is one of 17 sites throughout New Zealand where native plants have been planted to leave a legacy of New Zealand's hosting of the Rugby World Cup. These community planting projects are collectively known as 'Living Legends' as each one is dedicated to a regional 'Rugby Legend'. In 2011 and 2012 over 30,000 plants (many donated by Auckland Waikato Fish and Game Council and Taupiri Marae through agreements with NZTA) were planted by volunteers in this management unit as part of Living Legends. Another 3,000 plants will be planted in 2013, the final year of the Living Legends project, resulting in most of this unit being revegetated.

Department of Conservation staff undertook extensive control of grey willow, crack willow and blackberry prior to the plantings. The clearance of willow along the lake edge has resulted in the regeneration of *Carex virgata* and *Carex secta* in this habitat. There are currently very few weeds in this management unit due to ongoing ground control of weeds by DOC.

It is recommended that areas of high ground in this management unit are left unplanted as they provide useful areas for passive recreation close to the main entrance of the lake.

Target habitat types for this management unit are listed in Table 8, along with recommended management actions.

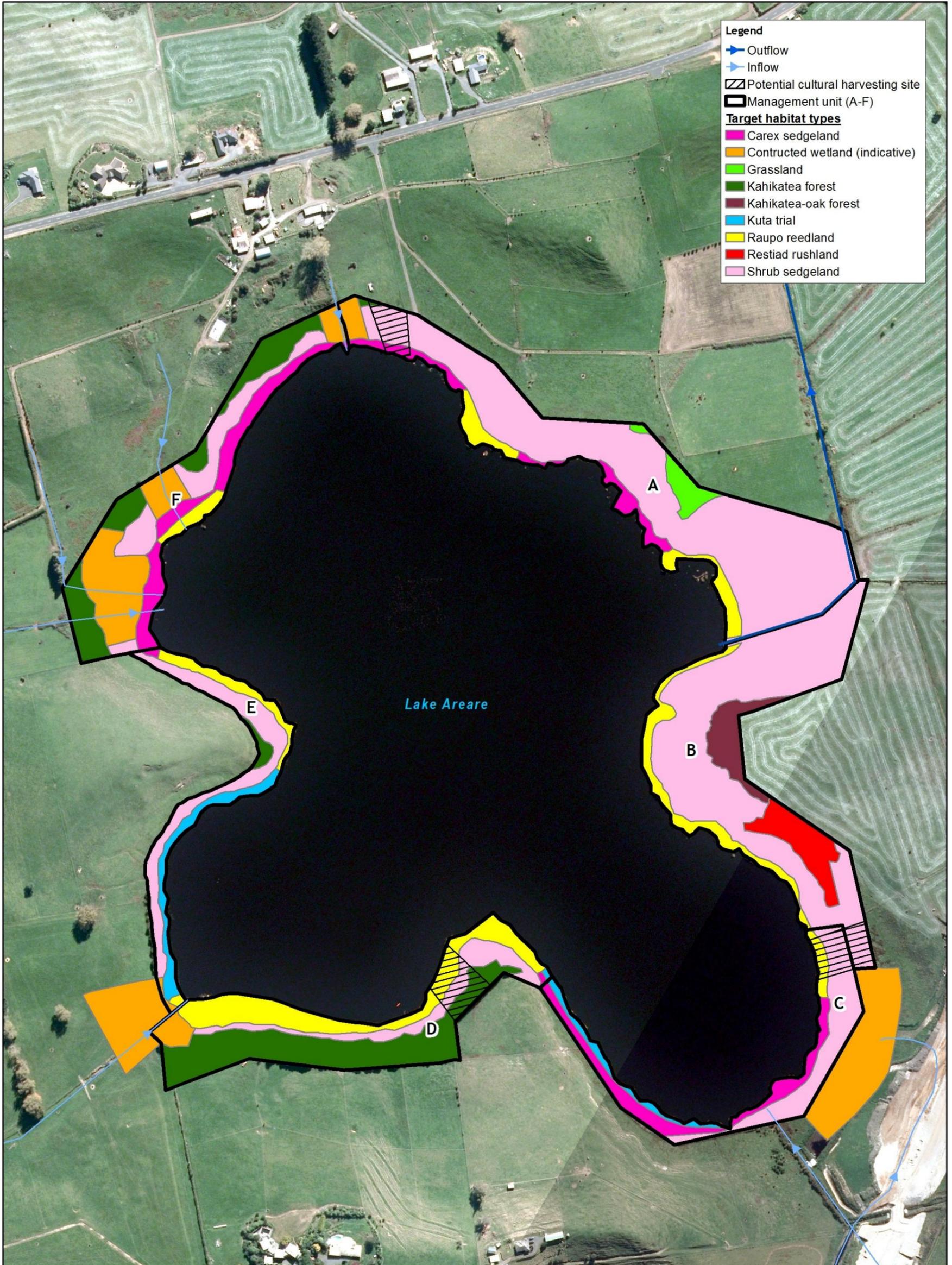
Table 8: Target habitat types for Management Unit A and recommended management actions.

Target Habitat Type	Management Actions	Suggested Timing
Raupo reedland	• Plant gaps with enhancement plants for this vegetation type (Table 5).	2014
	• Control any grey willow and crack willow that regenerate.	Ongoing
<i>Carex</i> sedgeland	• Plant gaps along lake edges with <i>Carex secta</i> and <i>Carex virgata</i> .	2013
	• Control grey willow and crack willow that regenerate.	Ongoing
Shrub sedgeland	• Plant gaps with enhancement plants for this vegetation type (Table 5).	2014
	• Control blackberry, gorse, grey willow and crack willow.	Ongoing
Grassland	• Control blackberry and gorse.	Ongoing

6.2 Management Unit B: Eastern margin

Management Unit B covers the eastern margin of the lake from the outflow to where the band of willow around the southern side of the lake begins. It contains the largest areas of raupo reedland and *Machaerina rubiginosa* sedgeland.

This area has received the least amount of management due to being difficult to access. Willow was aerially sprayed in 2011 however some willows were not killed and have subsequently regenerated. This management unit also includes several stands of mature gorse, large patches of blackberry and dense infestations of Beggar's tick. Pampas, gorse and blackberry are also scattered throughout this management unit.

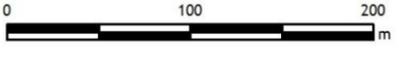


- Legend**
- Outflow
 - Inflow
 - ▨ Potential cultural harvesting site
 - ▭ Management unit (A-F)
- Target habitat types**
- Carex sedgeland
 - Constructed wetland (indicative)
 - Grassland
 - Kahikatea forest
 - Kahikatea-oak forest
 - Kuta trial
 - Raupo reedland
 - Restiad rushland
 - Shrub sedgeland

Data Acknowledgment
 Imagery sourced from NZ Aerial Mapping Limited and is the property of NZAM and the Waikato Regional Aerial Photography Syndicate (WRAPS) 2012. Copyright reserved.

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Figure 4: Lake Areare management units and target habitat types



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 Cartographer: FM
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Soil maps indicate that this area contains the deepest peat within the reserve and is therefore the best site to establish restiad rushland. Other target habitat types are listed in Table 9 along with recommended management actions.

Preliminary results from a telemetry study of waterfowl by Auckland Waikato Fish and Game Council indicate that many birds are nesting in pure stands of *Carex secta* (David Klee pers. comm.). It is therefore recommended that within this management unit, which is the largest re-vegetation area remaining, that *Carex secta* is planted in clusters within the *Carex* sedgeland and shrub sedgeland habitat types to provide good quality nesting habitat for waterfowl.

Table 9: Target habitat types for Management Unit B and recommended management actions.

Target Habitat Type	Management Actions	Suggested Timing
Raupo reedland	<ul style="list-style-type: none"> Plant gaps with enhancement plants for this vegetation type (Table 5). Control regenerating grey willow and crack willow. 	2015
<i>Carex</i> sedgeland	<ul style="list-style-type: none"> Plant gaps along lake edges with <i>Carex secta</i> and <i>Carex virgata</i>. Control grey willow and crack willow that regenerate. 	2014
		2015
Shrub sedgeland	<ul style="list-style-type: none"> Continue to control blackberry, gorse, grey willow and crack willow to maximise natural regeneration. After 2 years plant gaps with enhancement plants for this vegetation type (Table 5). 	Ongoing
		2015
Restiad rushland	<ul style="list-style-type: none"> Undertake site preparation to clear the target area of all vegetation except <i>Machaerina rubiginosa</i>. Densely plant 40% of the target area with <i>Empodisma robustum</i> and another 40 % with <i>Sporadanthus ferrugineus</i>. Plant the remaining 20% of the site with enhancement plants listed for this vegetation type (Table 5). 	2015
		2016
Kahikatea forest	<ul style="list-style-type: none"> Clear with machinery (if possible) the large stands of mature gorse. Spray with herbicide then plant with 'open site' species for this vegetation type including large (PB5-8) kahikatea and matai. Leave oak trees but control weeds beneath and establish an indigenous understorey with enhancement plants suitable for this vegetation type (Table 5). 	2015
		2015 / 2016

6.3 Management Unit C: Grey willow forest

Management Unit C includes the remaining area of grey willow forest (including some crack willow and weeping willow) near the main inflow. This area is now partly hemmed by the NZTA constructed wetland. The margin between the grey willow forest and the reserve boundary is dominated by the worst infestation of blackberry within the reserve. It is recommended that these weeds be aerial sprayed with herbicide followed up by ground control. As there are small remnants of the target habitat types beneath the grey willow canopy it is recommended that planting be

delayed by at least 18 months to 2 years to allow natural regeneration to occur. Weed control will need to be ongoing during this period.

Kuta was common immediately west of the inflow back in 1993 and there are still some very sparse patches remaining. This area has therefore been identified for trialling the re-establishment of kuta beds once willow has been removed from this area. Management recommendations for other habitat types are listed in Table 10.

Table 10: Target habitat types for Management Unit B and recommended management actions.

Target Habitat Type	Management Actions	Suggested Timing
Raupo reedland	<ul style="list-style-type: none"> Aerial spray all willow. Plant gaps with enhancement plants for this vegetation type (Table 5). Control any willow that regenerate. 	2014 2016 Ongoing
<i>Carex</i> sedgeland	<ul style="list-style-type: none"> Aerial spray all willow. Plant gaps along lake edges with <i>Carex secta</i> and <i>Carex virgata</i>. Control grey willow and crack willow that regenerate. 	2014 2016 Ongoing
Shrub sedgeland	<ul style="list-style-type: none"> Aerial spray blackberry and gorse. Prepare site for planting buy removing all weeds and grasses. Plant site with 'open ground' species for this habitat type (Table 5). 	2014 2015 2016
Kuta trials	<ul style="list-style-type: none"> Aerial spray all willow. Cluster plant with kuta. 	2014 2015

6.4 Management Unit D: Ti kouka - manuka scrub

Management Unit D includes the oldest plantings (ti-kouka - manuka scrub) within the reserve, a band of raupo along the lake margin and an area of mixed indigenous and exotic herbs and grasses between these two habitat types. The goal within this management unit is to enhance the oldest plantings to create kahikatea forest and to revegetate the area of mixed indigenous and exotic herbs and grasses to create the shrub sedgeland habitat type.

It is recommended that exotic trees (e.g. oak) that have been planted by hunters be removed from this area to allow for the creation of kahikatea forest. Management recommendations for other target habitat types are listed in Table 11.

Table 11: Target habitat types for Management Unit D and recommended management actions.

Target Habitat Type	Management Actions	Suggested Timing
Raupo reedland	<ul style="list-style-type: none"> Control willow, gypsywort and beggars tick. Plant gaps with enhancement plants for this vegetation type (Table 5). 	2014 2014
Shrub sedgeland	<ul style="list-style-type: none"> Prepare site for planting buy removing all weeds and grasses. Plant site with 'open ground' species for this habitat type (Table 5). 	2014 2014
Kahikatea forest	<ul style="list-style-type: none"> Control inkweed, remove oaks and other exotic trees. Plant with 'enhancement planting' species for this vegetation type (Table 5). 	2014 2014 / 2015

6.5 Management Unit E: Mixed plantings

Management Unit E includes the narrow area of reserve between the lake and adjoining farms. Most of this area has already been planted and requires enhancement plantings to improve habitat diversity and spot spraying of the localised patches of blackberry (Table 12).

Management Unit E contains the largest remnant populations of kuta at the lake making it an ideal area to trial kuta plantings. Before planting takes place it is recommended that some lake marginal plant communities are controlled. Target species to control include willow primrose, water purslane, water pepper and swamp willow weed (indigenous herb). These species are currently smothering the existing stands of kuta.

Table 12: Target habitat types for Management Unit E and recommended management actions.

Target Habitat Type	Management Actions	Suggested Timing
Raupo reedland	<ul style="list-style-type: none"> Plant gaps with enhancement plants for this vegetation type (Table 5). Control willow. 	2014 Ongoing
Kuta trial	<ul style="list-style-type: none"> Control marginal vegetation (water purslane, swamp primrose willow, water pepper and swamp willow weed) before planting kuta. Cluster plant with kuta. 	2014 2015
Shrub sedgeland	<ul style="list-style-type: none"> Plant gaps with enhancement plants for this vegetation type (Table 5). Leave oak tree to provide food for waterfowl and roosting for shags. 	2014
Kahikatea forest	<ul style="list-style-type: none"> Move fence out to the reserve boundary. Plant with 'open site' species for this vegetation type (Table 5). 	2015 2016

6.6 Management Unit F: Western margin

Management Unit F on the western margin of the lake contains some recent plantings (1-4 years old) near the lake margin and was aerially sprayed in 2011 to remove blackberry and willow. There has been only a small amount of willow regeneration however blackberry is beginning to dominate some parts of this management unit although plants are still quite small.

Three constructed wetlands are planned for this area and are likely to be built in 2015. Construction of the wetlands will require heavy machinery and it is therefore recommended that revegetation is delayed until after these have been built (Table 13).

It appears that this section of the lake margin has been used to dump rubbish including concrete and old tyres which are unsightly and also present a hazard to lake users. It is recommended that the rubbish is removed before undertaking further planting along the lake margin.

Table 13: Target habitat types for Management Unit F and recommended management actions.

Target Habitat Type	Management Actions	Suggested Timing
Raupo reedland	<ul style="list-style-type: none"> Remove rubbish along lake margin. Plant gaps with enhancement plants for this vegetation type (Table 5). Control any grey willow and crack willow that regenerate. 	2013 2015 Ongoing
<i>Carex</i> sedgeland	<ul style="list-style-type: none"> Remove rubbish along lake margin. Plant gaps along lake edges with <i>Carex secta</i> and <i>Carex virgata</i>. Control grey willow and crack willow that regenerate. 	2013 2015 Ongoing
Shrub sedgeland	<ul style="list-style-type: none"> Undertake site preparation by spraying rank grassland and any weeds present. Plant with 'open site' species for this vegetation type. 	2015 2016
Kahikatea forest	<ul style="list-style-type: none"> Undertake site preparation by spraying rank grassland and any weeds present. Plant with 'open site' species for this vegetation type. 	2015 2016

7. MONITORING AND MAINTENANCE

7.1 Monitoring

Regular monitoring of the site should be undertaken to identify what management intervention might be required, and when, to ensure restoration goals are met. Site inspections should be undertaken at regular intervals immediately following planting, with a particular focus on monitoring plant survival and whether animal pests are present. In addition to site inspections, a simple monitoring system of photopoints should be established at appropriate locations to record changes in vegetation composition. These should be installed prior to the commencement of any physical works, and should be re-photographed prior to and immediately following planting

and at least annually thereafter. Photopoint monitoring consists of repeat photography in the same location, over a period of time to monitor vegetation and ecosystem change.

7.2 Maintenance

Post-planting maintenance can be as critical as thorough site preparation in terms of ensuring a successful outcome to a restoration project. Overtopping and/or competitive pressures exerted by weeds or grasses need to be avoided by timely and appropriate intervention.

Weed control and releasing will need to be undertaken for at least 24 months following planting to ensure the successful establishment of the plantings. During the first year, some plants may need to be released from weed competition twice or more, and 1-2 times in the year thereafter. This is likely to be true of root trainer stock proposed. The PB sized plants are likely to require less frequent attention but nevertheless will need to be monitored closely.

Post planting animal pest control may need to be implemented if animal damage is detected during site inspections.

ACKNOWLEDGMENTS

John Gumbley (Department of Conservation) is thanked for providing project liaison, guidance on many aspects of the report, and feedback on the draft report. Tracie Dean-Speirs (Waikato Regional Council) provided information from WRC and feedback on the draft report. Mike Paviour and Craig Purvis (Department of Conservation) provided information on the historical and current management of the site.

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VASCULAR SPECIES LIST

Planted species are indicated with ‘*’.

INDIGENOUS SPECIES

Gymnosperms

<i>Dacrycarpus dacrydioides</i> *	kahikatea
<i>Dacrydium cupressinum</i> *	rimu
<i>Podocarpus totara</i> var. <i>totara</i> *	totara

Monocot. trees and shrubs

<i>Cordyline australis</i>	tī kōuka, cabbage tree
----------------------------	------------------------

Dicot. trees and shrubs

<i>Alectryon excelsus</i> subsp. <i>excelsus</i> *	tītoki
<i>Coprosma</i> × <i>cunninghamii</i> (<i>Coprosma propinqua</i> × <i>C. robusta</i>)	
<i>Coprosma robusta</i> *	karamū, kāramuramu
<i>Coprosma tenuicaulis</i> *	hukihuki, swamp coprosma
<i>Leptospermum scoparium</i> agg. *	mānuka
<i>Melicytus ramiflorus</i> subsp. <i>ramiflorus</i> *	māhoe
<i>Pittosporum tenuifolium</i>	kōhūhū, rautāhiri, rautāwhiri
<i>Plagianthus regius</i> subsp. <i>regius</i> *	ribbonwood, mānātu
<i>Sophora tetraptera</i> *	kōwhai

Dicot. lianes

<i>Calystegia sepium</i>	
<i>Muehlenbeckia australis</i>	puka

Ferns

<i>Blechnum minus</i>	swamp kiokio
<i>Cyathea dealbata</i>	ponga, silver fern
<i>Cyathea medullaris</i>	mamaku
<i>Dicksonia squarrosa</i>	whekī
<i>Histiopteris incisa</i>	mātātā, water fern
<i>Hypolepis ambigua</i>	
<i>Paesia scaberula</i>	mātātā
<i>Pteridium esculentum</i>	rārahu, bracken
<i>Pteris tremula</i>	turawera, shaking brake

Grasses

Isachne globosa swamp millet
Lachnagrostis filiformis

Sedges

Carex lessoniana toetoe-rautahi
Carex maorica
*Carex secta** pūrei
*Carex virgata** pūrei
Cyperus ustulatus f. *ustulatus* toetoe upoko-tangata
Eleocharis acuta spike sedge
Eleocharis gracilis
Eleocharis sphacelata giant spike sedge, ngāwhā,
Isolepis prolifer
Isolepis reticularis
Machaerina articulata
Machaerina rubiginosa

Rushes

Juncus edgariae wi, wīwī
Juncus planifolius

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

Dianella nigra tūrutu
Lemna minor karearea
*Phormium tenax** harakeke, flax
Typha orientalis raupō

Dicot. herbs

Centella uniflora
Hydrocotyle pterocarpa
Lobelia anceps punakura
Lobelia angulata pānakenake
Myriophyllum propinquum
Persicaria decipiens

NATURALISED AND EXOTIC SPECIES

Dicot. trees and shrubs

Quercus robur. oak
Rubus sp. (*R. fruticosus* agg.) blackberry
Salix babylonica weeping willow
Salix cinerea grey willow
Salix fragilis crack willow
Solanum pseudocapsicum Jerusalem cherry

Ulex europaeus

gorse

Ferns

Azolla pinnata

ferny azolla

Grasses

Agrostis capillaris

browntop

Agrostis stolonifera

creeping bent

Anthoxanthum odoratum

sweet vernal

Cortaderia selloana

pampas

Glyceria fluitans

floating sweet grass

Holcus lanatus

Yorkshire fog

Lolium perenne

rye grass

Paspalum distichum

Mercer grass

Schedonorus arundinaceus

tall fescue

Sedges

Carex ovalis

oval sedge

Cyperus eragrostis

umbrella sedge

Rushes

Juncus acuminatus

sharp-fruited rush

Juncus articulatus

jointed rush

Juncus bufonius var. *bufonius*

toad rush

Juncus bulbosus

bulbous rush

Juncus dichotomus

forked rush

Juncus effusus var. *effusus*

soft rush, leafless rush

Juncus tenuis var. *tenuis*

track rush

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

Egeria densa

egeria

Landoltia punctata

purple-backed duckweed

Composite herbs

Achillea millefolium

yarrow

Aster subulatus

sea aster

Bidens frondosa

beggars' ticks

Cirsium arvense

California thistle

Cirsium vulgare

Scotch thistle

Euchiton involucratus

Hypochaeris radicata

catsear

Senecio bipinnatisectus

Australian fireweed

Dicot. herbs

<i>Callitriche stagnalis</i>	starwort
<i>Fumaria muralis</i>	scrambling fumitory
<i>Galium palustre</i>	marsh bedstraw
<i>Lotus pedunculatus</i>	lotus
<i>Ludwigia palustris</i>	water purslane
<i>Ludwigia peploides</i>	primrose willow
<i>Lycopus europaeus</i>	gypsy wort
<i>Lythrum hyssopifolia</i>	hyssop loosestrife
<i>Mentha pulegium</i>	penny royal
<i>Myosotis laxa</i> subsp. <i>caespitosa</i>	water forget-me-not
<i>Persicaria hydropiper</i>	inkweed
<i>Phytolacca octandra</i>	narrow-leaved plantain
<i>Plantago lanceolata</i>	broad-leaved plantain
<i>Plantago major</i>	spearwort
<i>Ranunculus flammula</i>	creeping buttercup
<i>Ranunculus repens</i>	clustered dock
<i>Rumex conglomeratus</i>	white clover
<i>Trifolium repens</i>	

PHOTOGRAPHS OF TARGET
HABITAT TYPES



Plate 1: Kuta reedland.



Plate 2: Raupo reedland.



Plate 3: Carex sedgeland.



Plate 4: Shrub sedgeland.



Plate 5: Restiad rushland.



Plate 6: Kahikatea forest behind raupo reedland and shrub sedgeland.



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