



# **Te Kohaka O Tuhaitara Trust Tutaepatu Lagoon Restoration Project**

February 2008



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## **Te Kohaka O Tuhaitara Trust**

## **Tutaepatu Lagoon Restoration Project**

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## 1 Introduction

MWH and sub-consultants Landcare (NZ) Ltd have been requested by Te Kohaka o Tuhaitara Trust (the Trust) to develop a restoration strategy for the Tutaepatu Lagoon that achieves the restoration vision of a lagoon with largely indigenous vegetation that supports mahinga kai and spiritual values. Public views of the lagoon are a priority, as this fosters appreciation of the lagoon's values. The focus of the restoration strategy was identified in the Working Concept Plans (July 2007) as the northern and eastern sides of the lagoon where boardwalks and tracks link to a planned carpark adjacent to Gladstone Road and which will open up sightlines from Tutaepatu to Kaiapoi Pa.

This restoration plan does not include specific methods for the restoration of habitats for mudfish and tuna (eel), as water quality and water table fluctuations have yet to be established.

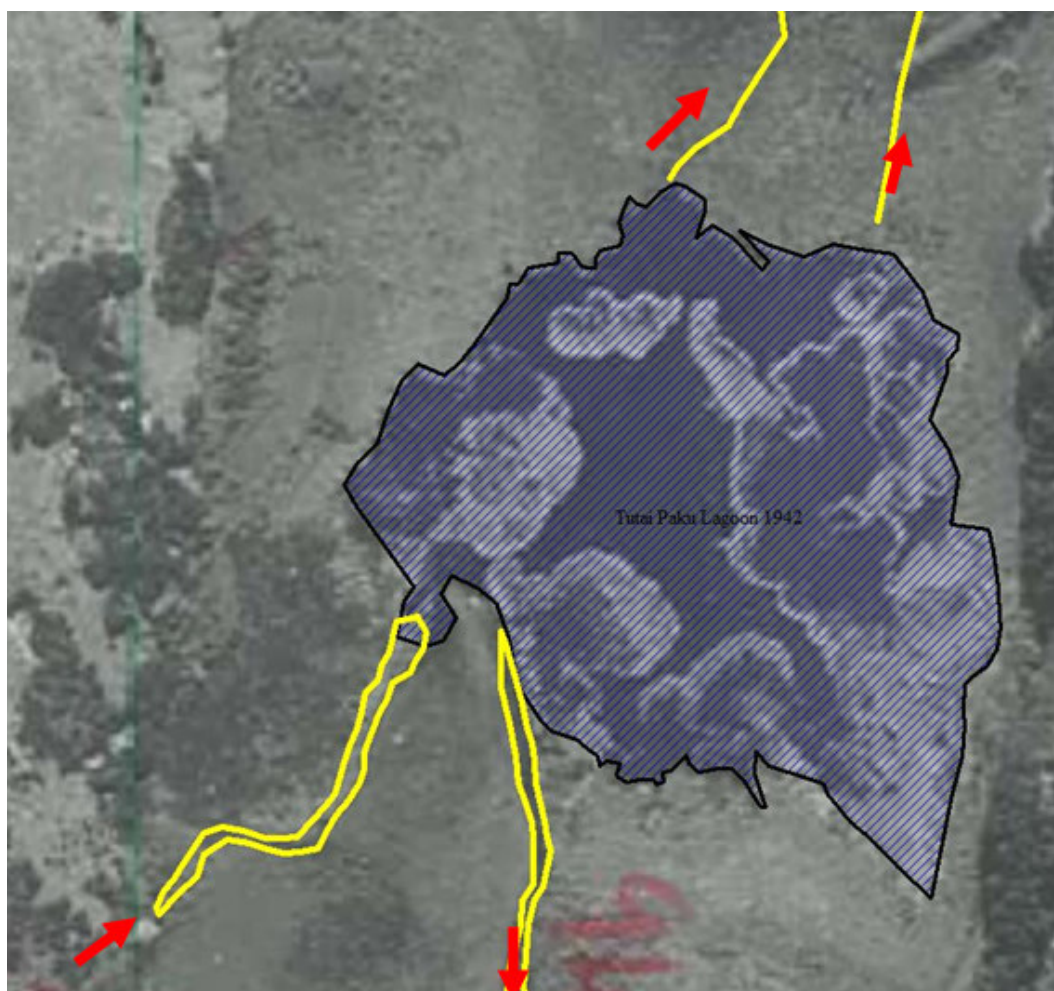


**Figure 1 : View west across Tutapatu Lagoon through dense will to remnant raupito lobe,  
December 2007**

## 2 Background

Tutaepatu Lagoon is the largest area of natural open water in a series of wetlands and lagoons that run parallel to the coast between the Waimakariri and Ashley Rivers. Some of these wetlands and lagoons have been drained, and some have been recently deepened and reshaped as part of the Pegasus Town development. However, the sequence of underlying soils and hydrological/topographic variation from driftwood-edged fore dune to periodically-flooded wetlands is largely intact making the area a valuable, but latent, ecological treasure.

The shallow Tutaepatu Lagoon is currently surrounded by a wide fringe of willows<sup>1</sup> that severely hamper access and prevent views of the lake from the ground. Figure 1 shows one of two remnant lobes of raupo present in the lagoon. These were part of an extensive emergent native vegetation cover which can be seen in aerial photographs dating from 1942 (Figure 2).



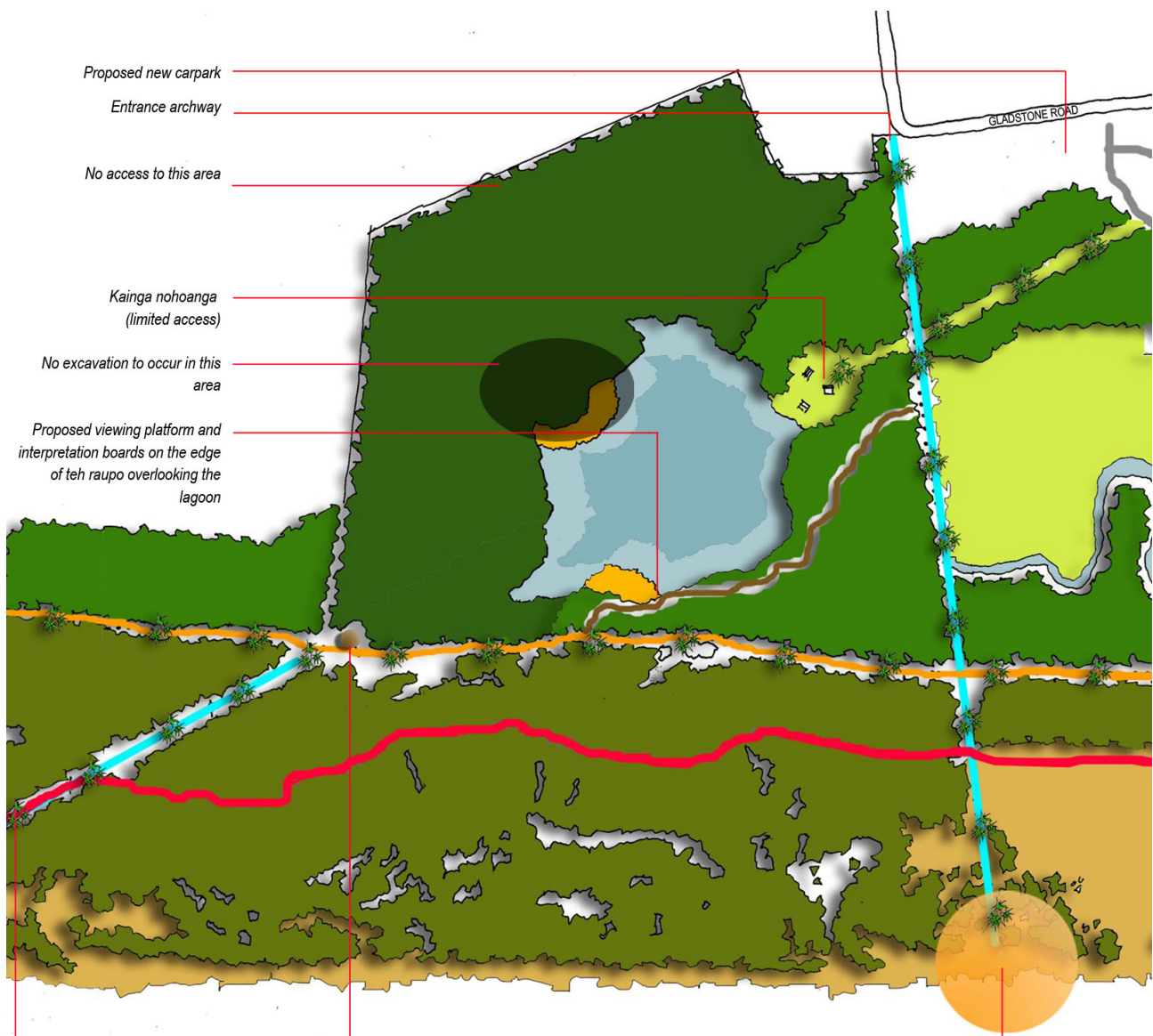
**Figure 2 : This aerial photo was taken in 1942. While the area of the lagoon is largely the same today, native vegetation cover was much more extensive**

<sup>1</sup> mainly grey willow (*Salix cinerea*, also called pussy willow) with some crack willow (*S. fragilis*).

The Tuhaitara Coastal Reserve and Waikuku Beach Reserves Management Plan (April 2006) identifies two key 'ecological' goals.

1. Restoration of the Tutaepatu Lagoon<sup>2</sup>, which specifically includes indigenous riparian planting (Policy 7.1.1), and
2. *'To promote natural regeneration of indigenous vegetation; identify and protect significant indigenous vegetation'*.

Based on these goals, working concept plans were developed in consultation with the Trust over several workshops, with the design intention *'to restore Tutaepatu's connection with Kaiapoi Pa while retaining its mystical and spiritual qualities and allowing for sourcing of mahinga kai'* (MWH, July 2007).



**Figure 3 : Lagoon restoration concept plan from Working Concept Plans (July 2007)**

<sup>2</sup> required under the Reserves Act 1977 and Ngai Tahu (Tutaepatu Lagoon vesting) Act 1998

### 3 Methodology and Concepts

Preparation of this restoration strategy required development of specific aims/outcomes consistent with the restoration concepts and ecological goals outlined in Section 2 above.

Two sorties were carried out through the area providing information on the native and exotic vegetation present in the lagoon area, its general distribution and abundance, and probable response to removal of willows using different methods.

The first sortie on 5 November traversed the eastern edge of the lagoon when extensive areas of standing water and duckweed were present. On 21 December the water table had dropped revealing peaty silt with access gained by thrashing through willow and blackberry along the northern edge of the lagoon from the elbow on Gladstone Road (near the proposed carpark) and south-eastern boundary with Pegasus Town, to the foredune (and back). All vascular plant species identified have been entered onto the New Zealand Biodiversity Recording Network by Colin Muerk (<http://www.nzbrn.org.nz/>). The species are found listed in Appendix 2. Significant native vegetation was identified as species that are regionally rare or on the margins of their range, and vegetation that can be the base or 'seed' for natural regeneration. Vegetation was not mapped.

The likely approaches and outcomes were assessed in the light of experiences in restoration of wetlands, coastal dunes and riparian areas in the Canterbury region, in particular, Travis Wetland, Otukaikino and the Groyne, all of which have re-established native wetland vegetation while balancing growth of dense willows and herbaceous weeds.

#### 3.1 The Restoration Vision – Specific Ecological Aims

This report details actions to achieve the general goals of a dominant native vegetation cover in the medium to long term and protection/enhancement of locally rare native species. The overall restoration philosophy is based on three tenets:

- A conservative approach, i.e.: avoiding techniques that commit the Trust to future high expenditure and maintenance in the future. This means using methods that have a low risk of failure but allow the building of knowledge about Tutaepatu by using a variety of approaches in the first few years and monitoring their effectiveness.
- Achieving goals over a 50 to 100 year timeframe. This promotes working largely with natural regeneration over the broader area, and using intensive, shorter term restoration in small high-profile areas<sup>3</sup>. It also promotes spending significant resources where they will have the most ecological benefit, and thereby limiting the extent of future weed control.
- Recognition that willows are a resource as well as a weed. The willow mounds and dead branches form refugia for native herbs, and cover for birds and invertebrates (hawks).

Control of weeds, some planting of native seed sources and management of willows are the core activities. Three methods are proposed to reduce the impact of willow - these have increasing levels of intensity, disturbance, cost and decreasing time to achieve a native-dominated system. A mix of the methods will be used depending on the location and level of resources available.

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<sup>3</sup> The intensive work will be done at access points and along the boardwalk where people have greatest contact with the Lagoon to maximize their experience and enthusiasm for restoration potential





**Figure 4 : Travis wetland, Christchurch is an area where a willow and weed-infested wetland is progressively being restored through managed weed removal and plantings of native species – the photo shows cabbage tree and ribbonwood emerging behind a fringe of flax and rushes, May 2007**

## 3.2 Outcomes from the Concept Plan

Specific outcomes supporting the restoration vision and ecological goals are listed in the Working Concept Plans. The outcomes, and the activities proposed to achieve them are listed below:

- Restore a predominantly native vegetation, in particular, increase the area of native reeds towards 1945 values, and create and expand wetland areas by removal of exotic species and encouraging native regeneration, and planting of native seed sources. Seed sources will include native trees and shrubs in 'oasis' or 'nodal' planting<sup>4</sup> on moist, rarely-flooded soils and common wetland sedges and flaxes planted in flooded areas, focusing initially near the boardwalk and paths, i.e., working from south-east corner towards the north to show-case restoration.
- Develop a *kainga nohoanga* in the north-western corner of the area (illustrated in Figure 3 : Lagoon restoration concept plan from Working Concept Plans (July 2007)Figure 3). This will need discussion with the local rohe to confirm preferred combinations of exclusion (e.g., screening planting from the walkway and road), signs, moating, and the area of gravel, grass and low plantings and potential for flax fibre-gardens for weavers (link to Landcare Research website). Depending on the envisaged times of access and duration of visits, minor drainage may be desirable and access to the lake 'edge' boarded or graveled. Vehicle access to the lake edge is not envisaged. Timing of this development is unknown at this stage and will be directed largely by consultation.
- Strengthen the connection between Kaiapoi Pa and the Lagoon, and the Lagoon to the Sea by removing willows to create continuous sightlines, interpretation signs and avoiding planting trees and plants over 3 m height in the corridor. Access to the south-eastern corner will be limited by not locating tracks in this segment – and could include signs warning of falling willow trees.

<sup>4</sup> A few areas up to 0.25 ha each in areas with rapid growth to minimise the maintenance period



**Figure 5 : An early sketch showing possible lagoon to sea concept**

- Retain mystique of lagoon through limiting views of the lake, by manipulating the height and location of the boardwalk in relation to vegetation height (raupo and flax grow to c.2m height) and the length of boardwalk near the edge of open water.
- Prohibit and exclude dogs and horses– existing signs are very old and sparse, and not at the main access points nor at proposed access points. Dogs can be actively excluded from the boardwalk using gates, moats and planting. Horses can be encouraged to use Woodend Domain where horse-truck, hitching and watering facilities are proposed, and discouraged by ensuring the carpark near the Lagoon is difficult to park horse-trucks, has no links with bridle paths, and signs directing horses to Woodend. Monitoring and enforcement by a ranger coupled with marketing and education brochures will assist as part of the restoration.
- Restore flows into and out from the lagoon via the original watercourses of Taranaki Stream, Saltwater Creek and Waiora Stream, so that they support the fish and plant populations sourced from them in the past
- Improve water quality to support fish populations fit for human consumption. Water quality is likely to change as the willow canopy is reduced, particularly where the willow canopy extends over water in summer. Expect temperatures to increase (due to less shading) and dissolved oxygen levels increase (perhaps seasonally) as less willow leaves are grown and dropped into open water (where they decay, using oxygen).
- Maintain and enhance populations of locally or regionally rare native plants.



**Figure 6 : Otutaikino wetland, Christchurch. Willow is being removed, allowing native species to regenerate – here a dense stand of raupo with Carex secta and kiokio fern, December 2007.**

## 4 Current Situation

### 4.1 Existing Vegetation

Vegetation in the lagoon area is currently dominated by a dense cover of grey and crack willows, with the exception of two lobes of dense raupo edging open water (Figure 1). Most of the willow-dominated area has a shallow cover of water in winter, with floating *Azolla* covering the surface in spring. A narrow range of native wetland plants survive in the shade of the willows amidst dead stumps of *Carex secta* and tree fern. A few clumps of flax are found in the brightest areas, however, the most common species on the eastern side of the lake are tussock sedges (*Carex secta* and *C. virgata*), *Eleocharis acuta*, and exotic rushes *Juncus articulatus* and *J. effuses*. Larger willows have created small (1 to 2 m<sup>2</sup>) islands above the otherwise flat surface (Figure 7). These 'islands' are where the majority of native vegetation is found: the tussock sedges, swamp kiokio (*Blechnum minus*), *Hypolepis ambigua*, minigimigi (*Coprosma propinqua*) and very occasionally flax and cabbage trees. On both these islands and on rotting willow logs epiphytic ferns occur in localized patches: *Asplenium flaccidum*, *A.oblongifolium* and *Microsorium pustulatum* with *Asplenium terrestre* and *Blechnum penna-marina*. Islands among willows along the northern boundary are a refuge for some special native herbaceous plants that have been smothered out of adjacent pasture/open wetland, notably *Oreomyrrhis ramosa* and *Potentilla anserinoides*, a thornless rose resembling a buttercup (Figure 8).

Other than willow, exotic plants are sparse in these areas of seasonally high water table. The islands that form refuges for natives are also the areas from where weeds will colonise the wetland unless they are sprayed prior to willow control. Briar rose, blackberry, male fern, lotus and spindleberry are of most concern, the various grasses present can be left as a preferred exotic cover, except where they might smother the special refuges. Silver poplar (*Populus alba*), silver birch (*Betula pendula*) cotoneaster were not seen within the lagoon area, but are adjacent weeds that should be controlled.



**Figure 7 : Remnant vegetation under tall grey willow includes kiokio fern on 'islands' created by old willow trees and remnant *Carex secta* (far left). Together with the sparse rush (foreground), these plants would rapidly increase in density if willows were poi**

The most diverse woody native vegetation is found scattered through moist areas adjacent to the wetland and includes: *Coprosma propinqua*, *Coprosma robusta*, cabbage tree, flax, *Carex flagellifera*, *Carex maorica*, *C. secta*, *C. virgata*, kiokio, *Muehlenbeckia australis* and tarata (*Pittosporum eugenoides*), *Polystichum vestitu* and swamp nettle (*Urtica linariifolia*). In drier areas, particularly along the edges of main track, the occasional *Coprosma crassifolia*, cabbage tree, and kohuhu (*Pittosporum tenuifolium*) can be found. A large matagouri was seen near the north-western corner of the area. Apart from clumps of kiokio and bracken, exotic plants dominate these moist to dry areas that do not flood: broom, pasture grasses, lupins, blackberry, or gorse depending on soil texture and depth to water table. Key native plants missing from the original vegetation in the moist areas are the podocarps kahikatea, totara and matai, pokaka, manuka, mapou (*Myrsine australis*), weeping mapou (*M. divaricata*), *Hebe salicifolia*, toetoe or hoheria (*Hoheria angustifolia*).



**Figure 8 : Some special native plants in the Tutae Patu Lagoon area: from left to right matagouri, the native rose-herb *Potentilla anserinoides*, swamp nettle (*Urtica linariifolia*) and *Asplenium* fern (December 2007)**

Away from the lagoon, in damp hollows between sand dunes under a relatively dense pine trees were found patches of remnant native groundcovers: *Selliera radicans*, *Isolepis nodosa*, bidibid (*Acaena novae-zealandiae*) and the ferns kiokio, *Blechnum penna-marina* and *Asplenium flabellifolium*.

## 4.2 Native Birdlife and Insects

The general absence of any substantial areas of native plants may mask a thriving invertebrate fauna as many invertebrates are dependant on presence of trees, logs and leaf litter (i.e. not specific to individual plant species) and lack of regular disturbance. The wider lagoon area is likely to be a refuge for native invertebrates from the denuded and regularly disturbed plains. This is perhaps signaled by the native insectivores currently living in the forests: fantail, grey warbler, shining cuckoo and maybe ruru. Bellbirds are also present. The dense willow and pine forest cover and old, crib-dominated settlements mean many weeds have been largely suppressed or their naturalization slowed, however, there is a core of bird and wind-dispersed weeds that threaten native restoration plantings (e.g., ivy, spindle berry, blackberry, cotoneaster, boneseed, pampas, grey and crack willows, silver poplar) and the apparent recent increase in permanent residents and 'gardens' in the adjacent communities is bringing in plants known to be weeds in other areas of New Zealand (agapanthus, privet, monkey apple, palms).

## 5 Proposed Restoration Actions

Three key restoration actions must occur concurrently:

- weed control,
- establishing native seed sources and
- willow management.

Weed control and willow management will be needed annually and on an ongoing basis. Realisation of the huge restoration potential of the Tutaepatu lagoon area is limited by the following features, which can be overcome with planning and dedicated management:

- Weeds – both existing weeds and plants beginning to invade adjacent coastal strip (largely from gardens).
- Low numbers and diversity of native plant seed and propagule (propagation) sources
- Resources – restoration should be of a standard that generates community support and leverage.
- The community accepting restrictions on access and use of the area, e.g. exclusion of horses, dogs and vehicles.
- Ability to achieve effective animal pest control, particularly of rabbits (i.e., public acceptance of poisoning and trapping)

Each obstacle can be overcome with planning and dedication, adaptive management based on using a variety of methods, monitoring these areas to find what works (and what is not so effective) before scaling up as resources allow. This approach is called adaptive management and aligns perfectly with the long-term commitment of the Trust. Areas attacked should be small to begin with, and be managed to a low-maintenance state<sup>5</sup> before new areas are restored. Capital intensive developments such as structures (boardwalks, signs, fences, hides, track upgrades, etc.) can largely be overlaid onto the base restoration plan, except where they involve significant disturbance, and hence replanting /control of weeds.

### 5.1 Weed Control (apart from Willows)

Preceding willow clearance, prilling or aerial spraying with weed control is recommended to reduce the efforts required to control the likely surge in weed growth associated with increased light levels. The order of priority for weed control is:

1. young grey willow (<1m high will not be removed – crack willow and grey willow)
2. blackberry,
3. male fern,
4. briar rose (*Rosa rubiginosa*),
5. lotus,
6. and pampas.

Gradually the areas are expanded to include the pine plantations up to the top of the first sand ridge and at least 100 m along the main north-south (Tutaepatu trail) tracks – weeds in these areas include pampas, silver poplar, ivy, climbing asparagus, (*Asparagus officinalis*), silver birch (*Betula pendula*), spindleberry, periwinkle and cotoneaster. Most of these weeds have small, isolated populations<sup>6</sup> and removing them now greatly reduces the effort needed to control their

<sup>5</sup> i.e. wait until a dominant native canopy cover is reached before planting further areas or decreasing willow canopy in new areas. From past experience it is likely each new area will need repeated herbiciding to suppress willow, blackberry, briar rose and male fern for 2 to 4 years.

<sup>6</sup> There are extensive areas of ivy to the south of Tutaepatu

populations in the future. Important weeds to identify and remove are strangling climbers (ivy), smothering groundcovers (climbing asparagus), and woody weeds that are shade tolerant and bird-dispersed (spindleberry). New or potential invaders from further a field, but within the coastal strip, include cherry, agapanthus and some palms. Leave gorse, broom and lupins in general except within 10 to 20 m of plantings and along boundaries.

During works, precautionary measures, such as boot cleaning and washing down of equipment, should be undertaken to ensure that aquatic weed species such as *Didymo* are not accidentally introduced to the lagoon.



**Figure 9 : Waitarua Wetland, Auckland. Willows have been removed and native flaxes and sedges mass-planted adjacent to a 'hide', helping people observe wetland birds, July 2007.**

## 5.2 Planting native seed sources

The species and density of planting depends on the water table and light levels in the area being planted. All planting needs to be preceded by weed control to reduce the maintenance input after planting, as weeds will generally respond faster than natives to an increase in light levels associated with weed removal.

Five types of planting and management areas are recommended:

- A. Planting in areas cleared of willow,
- B. where willows are poisoned and left standing, but no planting is required,
- C. where willows are poisoned, left standing and planting is required,
- D. planting of tree 'nodes' for seed sources.
- E. Kainga nohoanga site

These types correspond to the areas mapped and labelled in drawing RS01.

## **A. Planting in areas cleared of willow**

**Area:** 20,500m<sup>2</sup>                      **Timing:** Years 1 and 2

This area adjoins the proposed boardwalk (Track C) and the proposed viewing platform (Track B). Given their proximity to the existing track and embankment along the eastern edge of the lagoon, we recommend that tree removal, planting and construction works start in this location and is carried out over a two year period. The area is approximately 22m wide (10m either side of the boardwalk).

Willows are felled and removed in this area allowing light-demanding species to be planted. Areas of peaty soils and standing water in winter and spring should be planted with *Juncus gregiflorus*, *J. sarophorus*, *Carex maorica* and *C. secta*, with occasional clumps of flax and cabbage trees at 2m spacing in areas with the shortest duration of ponding (Figure 9). No planting is to occur within 2m of existing native vegetation (often found on willow bases = 'islands'). Plant should occur when the water recedes in late spring/early summer to maximize the establishment time before ponded conditions return. Very few native woody shrubs or trees can establish in standing water, and planting onto the 'island' bases of willows is difficult, as there is little continuous soil. It is more effective to encourage shrubs and trees to self-seed onto these islands by establishing bird-dispersed seed sources on favourable sites adjacent to peaty, inundated areas (nodal planting).

## **B. Where willows are poisoned and left standing, but planting may not be required**

**Area:** 20,500m<sup>2</sup>                      **Timing:** Year 1

Areas labeled as 'B' are where willows are poisoned (either prilling or aerial spray) but left standing. All crack willow, female grey willows and male grey willows within 5m of the open lake water are to be poisoned. These areas may not need supplemental planting as the weakening of the willow will allow the expansion of raupo back into areas of standing water. It is not necessary to prill willows on dry land and poisoning must be combined with herbiciding of weed species existing under the willows.

Where planting is required, due to difficult access, we recommend that plantings are restricted to 1 or 2 'seeding' clusters of 10-15 plants at 2.5m spacings in areas with least native cover. Where possible plant seedlings in pairs on edges of raised base of willows not colonized by other natives (so they can root into aerated substrate and into the peat flats) to provide local seed source. A 2m wide track should be cut to each pocket to allow relocation and access with backpack spray. Do not allow cut willow branches to touch the ground to minimize respouting.

### **C. Where willows are poisoned, left standing, and planting is required**

**Area:** 84,200m<sup>2</sup>                      **Timing:** Year 3 onwards (Not to be started until area A has become established (dominant native cover, low annual weeding))

Areas C1, C2 and C3 are designed to open up sight lines and establish nodal plantings which can supplement existing native vegetation. Significant areas along the narrow eastern strip between lake edge and sand dunes have existing native vegetation or exotic rushes that do not need to be controlled. Where the density of native plants is less than about 1 per 5m<sup>2</sup> or 5%, clusters of *Carex secta* and *C. virgata*, should be planted. Where female grey willows are poisoned, clusters of flax should be planted under the poisoned trees where light levels will be highest. Plant after aerial herbiciding to minimise damage to planted seedlings (spraying is likely to be done as soon as willows are in full leaf (summer)).

The aim of nodal plantings is to establish a source of seeds and propagules that will invade the willow understorey, particularly the willow bases. These plantings should be on moist, sheltered areas of moist sands adjacent to the lagoon, starting on the eastern boundary (areas C1 and C2), and later including areas on the western boundary (area C3 - between carpark and wetland). These areas are the most favourable sites for a wide range of plants, allowing relatively fast growth rates. Their location near tracks helps achieve regular monitoring and maintenance, and can showcase progress to the public. Retain pine trees further than about 3 m from planted areas to take advantage of shelter (and often lower weed density). Species include those listed by CCC riparian guideline (Figure 10 and <http://www.ccc.govt.nz/Parks/TheEnvironment/StreamsidePlantingGuide.pdf>.) – moist sites, selecting a high proportion of species resistant to rabbit browse or able to be fitted with rabbit-proof collars, and/or spraying foliage with rabbit repellants at planting. Flax can be used adjacent to tracks with horse and bike access to deter entry to these areas. Suggest planting at 1.5 to 2.5 m spacing depending on the growth form of the plant, and clustering podocarps into groups of 5 to allow targeted, longer-term maintenance. Application of mulched or shipped pine to 100-150 mm depth appears to have helped survival of natives in the pipeline area. Maintaining a continuous grass cover between plants may help decrease rabbits + rabbit repellency.

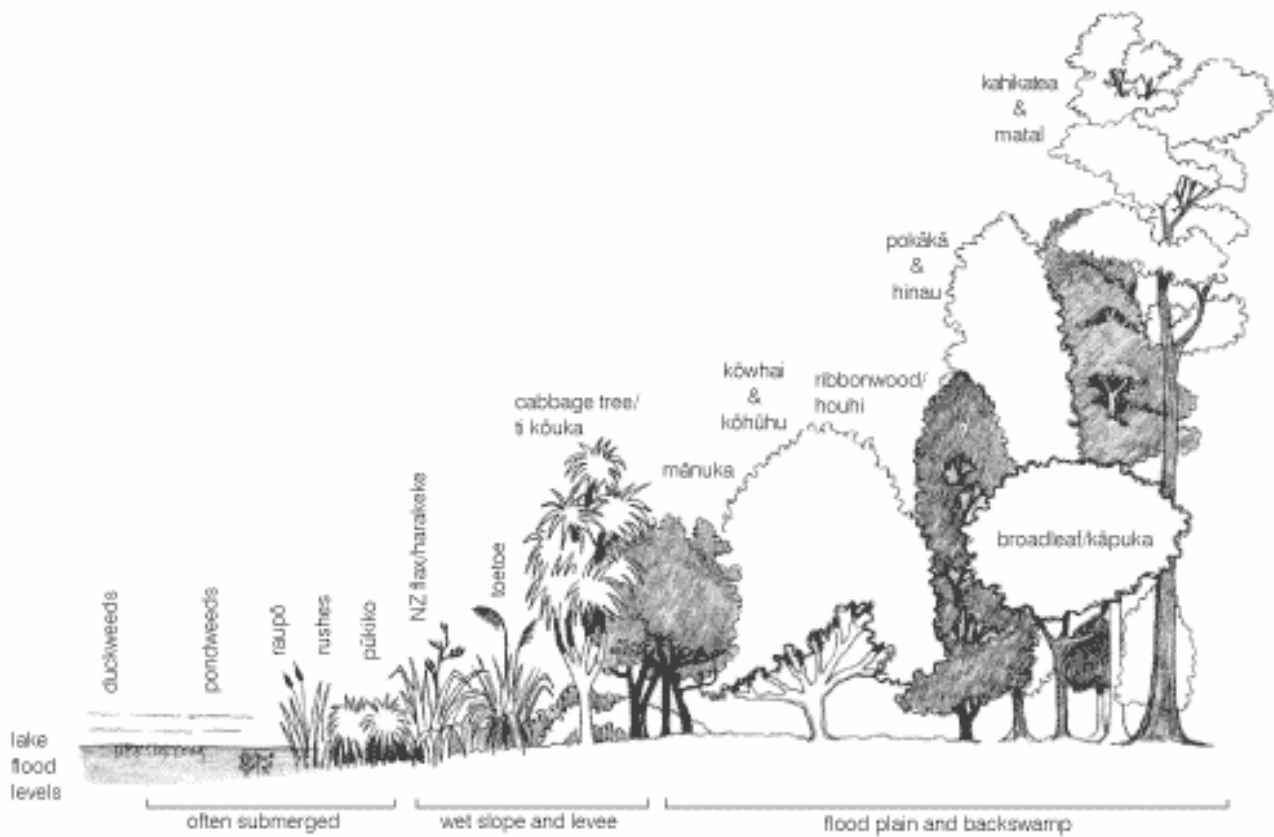
We recommend to start with a very small number of nodes up to 0.25ha each in the first 2 to 3 years (up to 4) of this stage ensuring resources to maintain weeds at low density are available, and ensure the resources required are recorded to allow planning in the future as resources are available. Nodes could be based around fire fighting ponds and/or existing remnants. In the medium term the nodes may be joined to create a buffer of native vegetation that shelters the wetland vegetation and helps filter wind-dispersed weed seeds, reducing reinvasion of weeds into drier lake edge from the pine plantation (e.g., pampas, grasses, poplars, lupin, male fern).

### **D. Planting of tree 'nodes' for seed sources**

**Area:** 44,300m<sup>2</sup>                      **Timing:** Year 1 onwards

Willows should not be controlled in Area D. The 110m wide strip runs along the northern boundary with the willows supporting populations of rare native plants. The willows should be subject to a careful adaptive management plan that involves first, releasing the native herbs from competition with exotic grasses and other groundcovers, and second, the very gradual poisoning of female grey willow and crack willow with the aim of maintaining the density of willow canopy that currently allows these herbs to be competitive.





**Figure 10 : Christchurch recommended riparian = lakeside planting**

## **E. Kainga Nohoanga Site**

**Timing:** To be determined through consultation

Consistent with the working concept plans developed with the Trust in 2007, a Kainga Nohoanga site is proposed in the northwestern corner of the lagoon. This site is to be developed in partnership with local iwi to provide a resource area where mahinga kai can be sourced and potential area for flax harvesting. The overall design and area required is heavily dependant on the requirements of the users.

### **5.3 Restoration and Willow Management**

Three concurrent approaches are recommended for controlling, and largely removing, willows in the areas outlined above.

**a) Willow removal and poisoning of stumps.** This is a very expensive option with high initial disturbance requiring supplemental planting (due to damage of existing native understorey) and high probability of weed invasion requiring intensive management for several years. This approach would initially be restricted to Area A1 where the installation of the boardwalk is to occur. This is to avoid the potential for trees to fall onto the track when poisoned.

Willows should be fallen close to the ground with care taken to minimize damage to native seedlings often found on the willow bases. Immediately coat the stump with either glyphosate herbicide, Vigilent gel or 5g metsulfuron/l litre with

penetrant. Branches should be stacked between 'islands' and off native vegetation, where they will dry out. Care is required so the branches do not contact the ground, or the branches may resprout (especially crack willow).

The entry point of the diggers for the construction of the boardwalk should be finalized by an ecologist/landscape architect, with the aim of avoiding disturbance to clusters of native vegetation (particularly ferns) and identifying a storage area for removed willows. This might include areas targeted as nodes to minimise clearance costs. We recommend the work be done by one digger driver only, who is shown the vegetation of value to avoid<sup>7</sup>, and with whom the willow felling / removal technique is developed. A long-reach digger may help minimise damage. We recommend removal in winter as saturated soils will not compact and willows are leafless or poisoned before removal and leave to dry out. Leave dead willow logs where they lie (do not remove).

**b) Blanket aerial spraying.** This is likely to require a resource consent. A trial in the strip along the eastern side (with relatively easy access for follow-up herbicide) and assess natural regeneration and weed control levels over 3 years before embarking on extensive aerial spraying. Current guidelines are to spray when the trees are in full leaf (late spring/summer/early autumn) with glyphosate and penetrant. An alternative is to poison just female grey willow from the ground, as described below.

**c) Poisoning female grey willow in situ using prilling.** Removal of female trees reduces the annual influx of seeds, hence reducing regeneration of new willow, and gradually increases light levels to the ground, allowing regeneration of native remnant vegetation. Two suitable trial areas would be the sightlines along the axis from the dunes to Tutae Patu Kaiapoi Pa (Areas C - if these are not aerially sprayed), and the areas immediately adjacent to the remnant raupo lobes (Areas B) with the aim of allowing natural expansion of raupo back into the willows. Female trees should be identified for removal in September/October, when they are flowering, with poisoning when plants are in full leaf (December through May). Poisoning involves either drilling a hole every 100 mm around the base of each tree at a 45 degree angle before injecting 10 ml of glyphosate or 2 ml of metsulfuron at 20g per 1 litre. Another recommended method is a single hole with 80 ml of glyphosate.

The public should be excluded from areas were willows have been poisoned as the dead trees become a hazard (falling on people as they clamber in and over them). If this technique is used near tracks (e.g. public tracks, or those used as part of weed or pest control), dead trees should be felled after several years to decrease the hazard. Logs should be left on the ground. This job requires a skilled chainsaw operator as it is hazardous work. Both aerial spraying and selective removal of female and lake-edge willows should be more effective once native seed sources are established and increasing numbers of natural regenerated seedlings under the willow canopy.

## 5.4 Track Development

**Track A** has the highest priority as it is required to provide access for the restoration works. This track is already of a good standard and will require upgrading in isolated locations. Eventually this track will form part of the longer Tutaepatu Trail or western alignment. Planting of *Cordyline australis* clumps are proposed at 50m intervals as route markers along with directional signs and information at key intersections.

**Track B** is the proposed viewing platform. The platform is designed to reflect the form of a tuna (eel) entering the lagoon and will rise at a gradient of 1in20 to a maximum height of 2m. The end of the platform is designed to give the

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<sup>7</sup> It will help if typical vegetation to be avoid can be marked with spray paint

appearance of being cantilevered out over the water. The platform will allow open views out across the lagoon and adjacent raupo plantings towards Kaiapoi Pa and Mt Grey. Carved pou are proposed at 10m centres starting at a height of 3m increasing up to 6m in height at the end. Hand railings are to be constructed where falls are greater than 1m and are to be constructed using rough sawn macrocarpa or locally sourced branches.

**Track C** will form a major pedestrian link between Tutaepatu Trail (Track A) and the planned carpark at Gladstone Road. This track is perceived as having a high priority for this reason, bringing people from Woodend and Pegasus into the lagoon. The track will be a boardwalk with its final alignment being determined on site to ensure existing native vegetation is not disturbed. Willow clearance for Area A will be carried out concurrently with the construction of the boardwalk.

**Track D** will form an additional pedestrian link between Gladstone Road and the reserves. This track is seen as having a low priority and will only be constructed if demand requires.

## 5.5 Monitoring

information still to be supplied.

## 6 Resource Consents

A suite of resource consents should be sought for all the lagoon restoration works. An application “bundling” the suite of applications to Environment Canterbury would be beneficial to streamline the consenting process, consultation and obtaining affected parties’ approval.

The following indicative list of consents has been recognised from the works associated with the restoration strategy. This list builds on greater detail than that outlined in the Working Concept Plans (MWH 2007).

### Land Use Consents

- Vegetation clearance within a riparian zone (WQL32)
- Disturbance or deposition of soil within a riparian zone
- Use, including storage, of a specified hazardous substance ((WQL 44)
- Erection or placement of structures (boardwalk and viewing platform) (BLR2)
- \*Excavation, drilling or disturbance within the bed (BLR3)
- \*Introduction or planting of plants (BLR4) and the disturbance of vegetation from removal (BLR5); subject to final review of works.
- \*Land use activities within 7.5m of the lagoon bed (BLR7)

\* These three works are covered as a discretionary activity under BLR8 (*structures, excavating, disturbance, planting, deposition, reclamation or drainage activities*).

### Discharge Permits

- Point source (WQL1) or discharge of hazardous substance into surface water or a liquid waste or a hazardous substance directly into groundwater (WQL46)
- Discharge of contaminants (sediment)

It would be advantageous to include the consents required for the geotechnical investigations in the necessary suite of consents for lagoon restoration. All consents would not only seek the initial activities, but also ongoing monitoring and maintenance over a 35 year term of consent.

## **7 Conclusion**

With restoration activities focusing on weed control and establishment of nodal seed sources, with a small initial planting effort and small initial willow removal areas (trailing the 3 techniques), it is anticipated this approach is likely to provide the greatest return for resources expended, ensuring the initial plantings are maintained of weeds (therefore successful) and allow gradual increase in local expertise in sand dune, forest and wetland planting.

## 8 References

MWH 2007 Working Concept plans

Trust – Coastal Management Plans

Christchurch City Council website: <http://www.ccc.govt.nz/Parks/TheEnvironment> Streamside planting guide (updated July 2005)

Global Invasive species database.

Harman H 2004: Feasibility of biological control of grey willow *Salix cinerea*. DoC Science Internal Series 183

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### NOTES

>>> **David J Compton-Moen** <[David.J.Compton-Moen@nz.mwhglobal.com](mailto:David.J.Compton-Moen@nz.mwhglobal.com)> 1/11/2007 4:31 p.m. >>>  
Hi Robyn,

*With reference to Mauricio's last findings, the water level of the lagoon will not change that much. The biggest problem according to M was that the in-out flow had gone and the lagoon had become stagnant. With the clearance of willows, M hoped that the flow may return but wasn't sure given the modification that has occurred in the area. Ideally, we would start the restoration coming in from the woodend beach end (close to where we stopped during the site visit) and work towards the northeast (Mt Grey). At the last workshop, we agreed that probably clearing 20m either side of the boardwalk would be a good start (any thoughts)*

**--- Robyn**

*include: \* key things to monitor - what responses to look for in water and vegetation,  
\* local examples of different approaches, and expected growth rates  
\* specific projects, e.g. boardwalk, podocarp groves, flax for harvesting, weed and pest animal controls  
The above allows a restoration plan to be a living document. At this stage the focus would be on I wouldn't expect to cover mahinga kai (but I gather water quality or eel harvesting for 'safety' is occurring - so the locals know when it is safe to start collecting again?) or waterfowl-mudfish enhancement*

Groundwater and surface water hydrology and water quality is likely to change in the short term as it is likely to be influenced by outcomes of Pegasus Township, recent changes in management of sewage ponds. There is also potential to increase the depth and area of permanent water and seasonally inundated areas – the management plan identifies that the original wetland was much larger than currently shown. Manipulation of water table may be possible through managing links with Pegasus Bay lakes, the existing drains (e.g. blocking drains on farmland owned by the Trust) and maybe replacing pines with less extractive plants; water quality may be managed by influencing farm drains, grazing practices and riparian and wetland vegetation cover.

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Test water quality in Lagoon for contact recreation standard and key mahinga kai (e.g. eel) for suitability for human consumption. Test during times and months when recreation is most likely and to identify times when water is most likely

and unlikely to be suitable (e.g. following storms if there is combined sewage stormwater system or grazing of cattle, or extended dry periods, algal blooms in summer)

### Oasis planting

The location provides visibility to public and ease of access for maintenance. Use to create visual surprises and support signs; track nodes.

- Existing native vegetation is often associated with open water – wetlands, fire-fighting ponds and streams/drains, and competing with willows. These should be the focus for hubs as here native vegetation is relatively resilient... and where native regrowth will occur spontaneously with removal of willows, also already signaled (useful to build on); Ensure where nodes are based on water supplies that an access strip to the water edge from the road is maintained in current state (confirm details of width, etc. with forestry and fire personnel – there may be restrictions on height of vegetation although the areas we saw often had willows). May be benefit in increasing the open water area in some of these nodes through excavation, blocking drains or diverting runoff from tracks.
- Avoid establishing hubs in areas with intransigent weeds, especially those that are tolerant of shade and are climbers e.g. do not establish in area infested with ivy. Also avoid blackberry as it is horrible for volunteers. Lupin and grasses are easiest to cope with followed by gorse.
- include groves of some slower growing, but ecologically critical trees that will provide key fruit resources for native birds and expect to inoculate undergrowth – e.g., kahikatea. Underplant kahikatea and ti kouka (cabbage tree) with species that will help smother weeds (and hence lower maintenance costs) e., harakeke (flax), manatu, karamu and kohuhu

200 year plan - Tutaepatu Lagoon enlarged, free of woody weeds source of healthy mahinga kai and full complement of native species (fish and birds); retaining its mystique through limited access points. The triangle completed between Kaiapohia Pa/monument (restoration of wetlands between Waikuku Beach and Tutaepatu lagoon) the lagoon and the coast with continuous native vegetation cover, and linked south through to the sea via a chain of rehabilitated streams/drains and wetlands (including Pines Beach wetlands) allowing migration of fish into lagoon for replenishment. Completely buffered against weed invasion with 100 m wide native vegetation buffer to farmed or forested land

Question: source of flax fibres would require specialist planted and tended area as per LCR guideline within easy walking distance of carpark (more like a garden than a wild area)

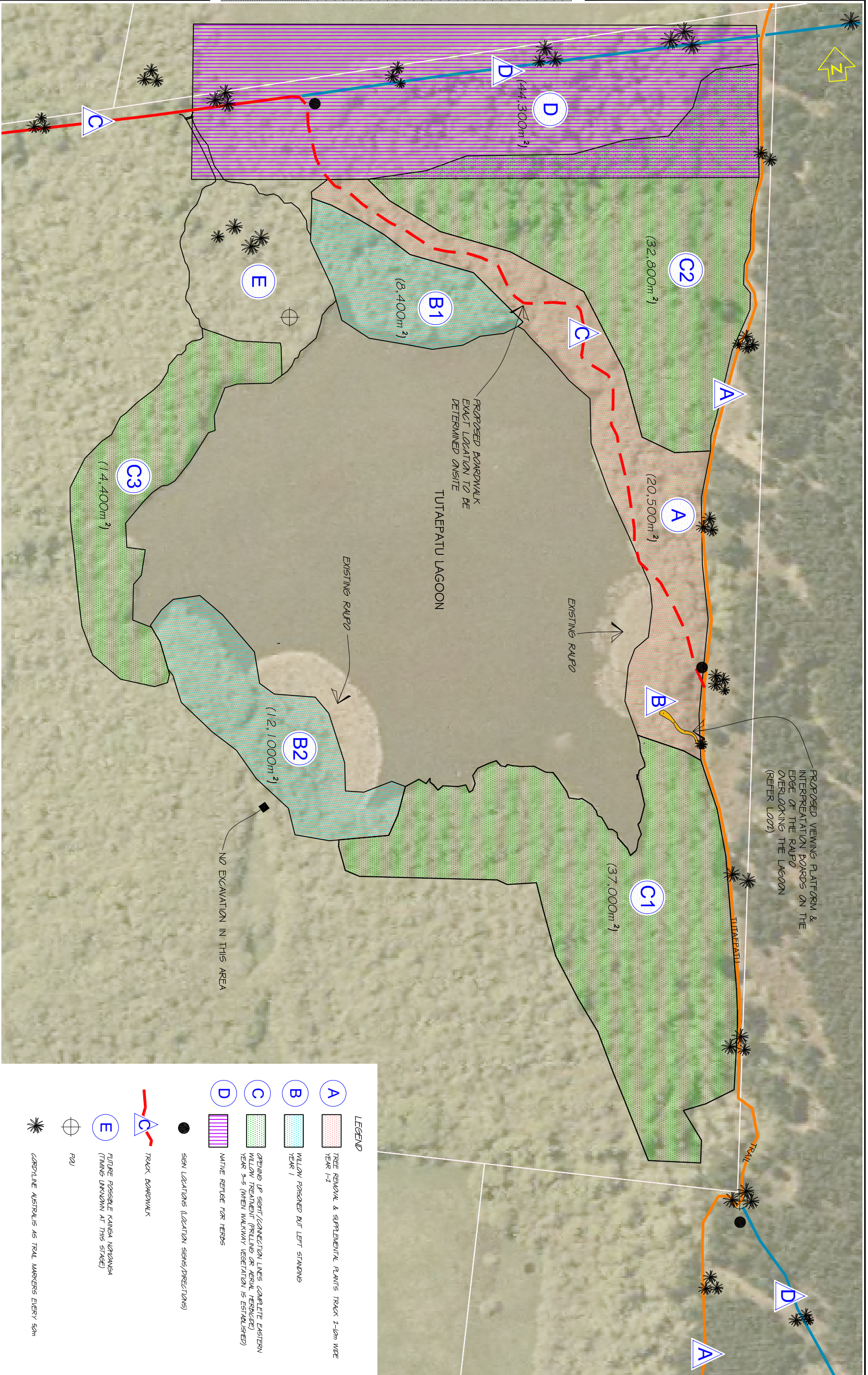
Moosaic of forest/dune ecologies containing podocarp forest – both forest and dunes supporting nesting populations of iconic and endangered native birds.. *potentially a mainland island of diversity unequalled in NZ via location on migratory bird route, and complex of ecosystems.* Production native forests of continuous cover native trees and small coupe harvesting supports weed and pest control programmes.

Ultimate goal of removing all willows, but utilizing a proportion of the less weedy willow species as shelter for native plants (as per lessons learnt in other wetland restoration projects in Canterbury region)



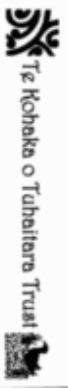
## Appendix A    Appendices





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PROJECTS: X\_Cadastra\_MP-2000-new\_X\_Aerial\_NZTM-NZGD2000



TUTAEPATU LAGOON

RESTORATION STRATEGY

FOR REVIEW

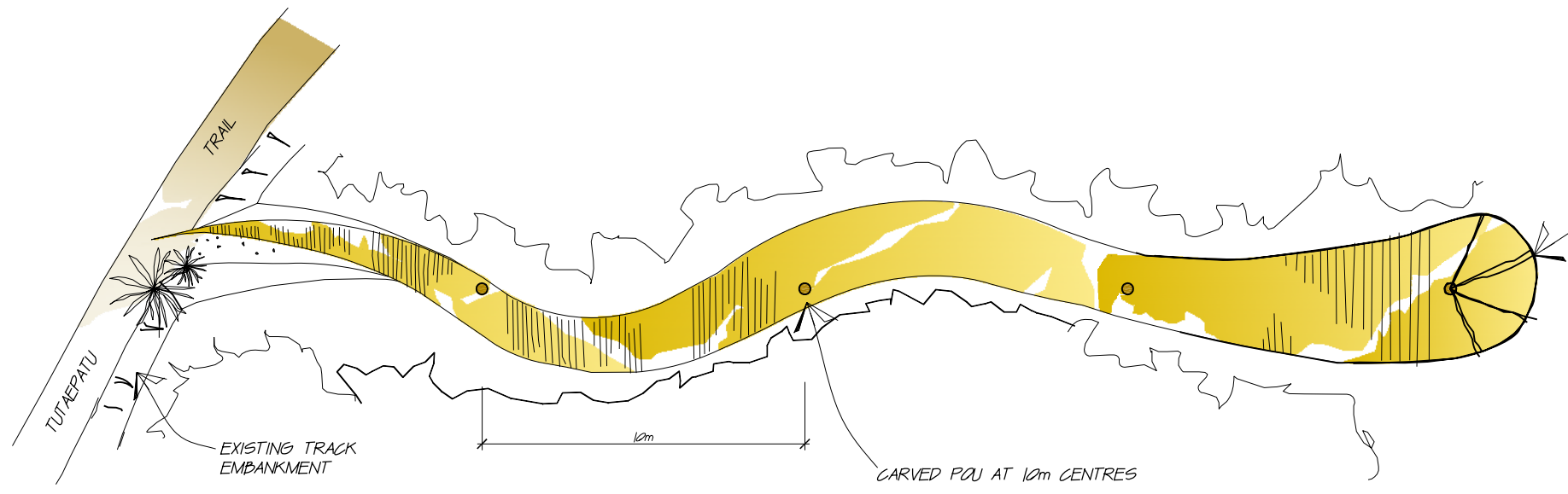
11/02/2008

SCALE: (A1) 1:250 (A3) 1:2500

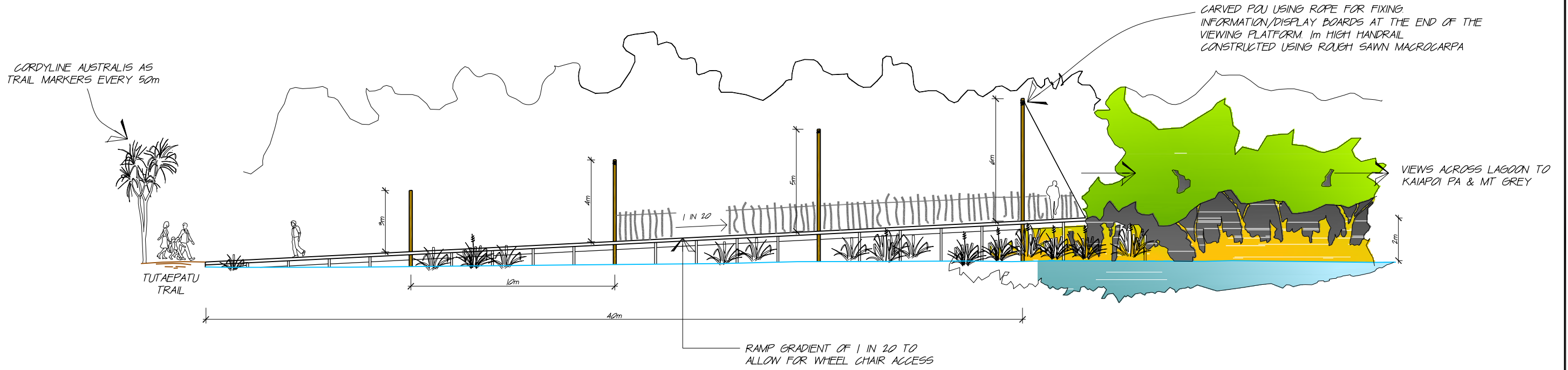
Sheet No: Z1609100 Rev: L 001 A

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DO NOT SCALE - IF IN DOUBT, ASK



PLAN OF VIEWING PLATFORM



ELEVATION OF VIEWING PLATFORM



**NOT FOR CONSTRUCTION**

		Name		Date		TUTAEPATU LAGOON		Status Stamp <b>FOR REVIEW</b>	
		SURVEYED				Tē Kohaka o Tuhaitara Trust		Date Stamp 11/02/2008	
		DESIGNED				MWH		SCALES (A1) 1:100 (A3) 1:200	
		DESIGN CHECK				PROPOSED VIEWING PLATFORM		Drawing No. Sheet No. Rev.	
		DRAWN						Z1609100 L002 A	
		DRAWING CHECK							
		APPROVED							
REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE				