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Opuatia Peat Bog Management Plan

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Date June 2011

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OPUATIA PEAT BOG
MANAGEMENT PLAN

APRIL 2011

Contract Report No. 2621

Report prepared for:

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CONTENTS

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1. INTRODUCTION

The Opuatia Wetland (950 ha) is situated north of Lake Whangape in the lower Waikato River catchment, North Waikato (Figure 1). Approximately 180 hectares of the wetland is peat bog, and the remainder is swamp and fen dominated by willow forest and manuka.

Opuatia Wetland is one of a handful of wetlands in New Zealand that contain areas of restiad bog. Restiad bogs are unique to New Zealand with peat being derived from restiad species, e.g. wire rush (*Empodisma minus*) and/or cane rush (*Sporodanthus ferrugineus*) rather than *Sphagnum* mosses. A number of threatened species inhabit Opuatia wetland including several orchids, carnivorous bladderworts, and long finned eel (Barnes *et al*. 2001). It is also good habitat for many other native fish, birds, and plants due to its size and mosaic of wetland types.

Waikato Regional Council (WRC) manages a 186 ha property at Opuatia which includes 90 ha of the Opuatia wetland, 29 ha of which is a young restiad peat bog fringed by fen and swamp. As mitigation for flood protection activities, WRC was required to develop and implement a management plan (Barnes *et al.* 2001) for the entire 90 ha wetland area. This management plan was developed in 2001 and has largely been implemented. WRC is looking to create a new management plan which is specific to the 29 ha peat bog area.

1.1 Project brief

The specifications for the work were to conduct the following within the 29 ha peat managed by WRC:

- Prepare a site map identifying the location of key plant communities;
- List all plant and bird species present in the project area, including recent planting undertaken by WRC;
- Describe (and where appropriate identify on map) current threats to the wetland;
- Identify information gaps/needs for progressing management;
- Identify and prioritise plant pests at the site and detail recommended methods and timing for control;
- Prepare a planting plan for the site including priority areas, plant spacings, recommended species, and timing;
- Recommend monitoring options including timing; and
- Prepare project timeline.

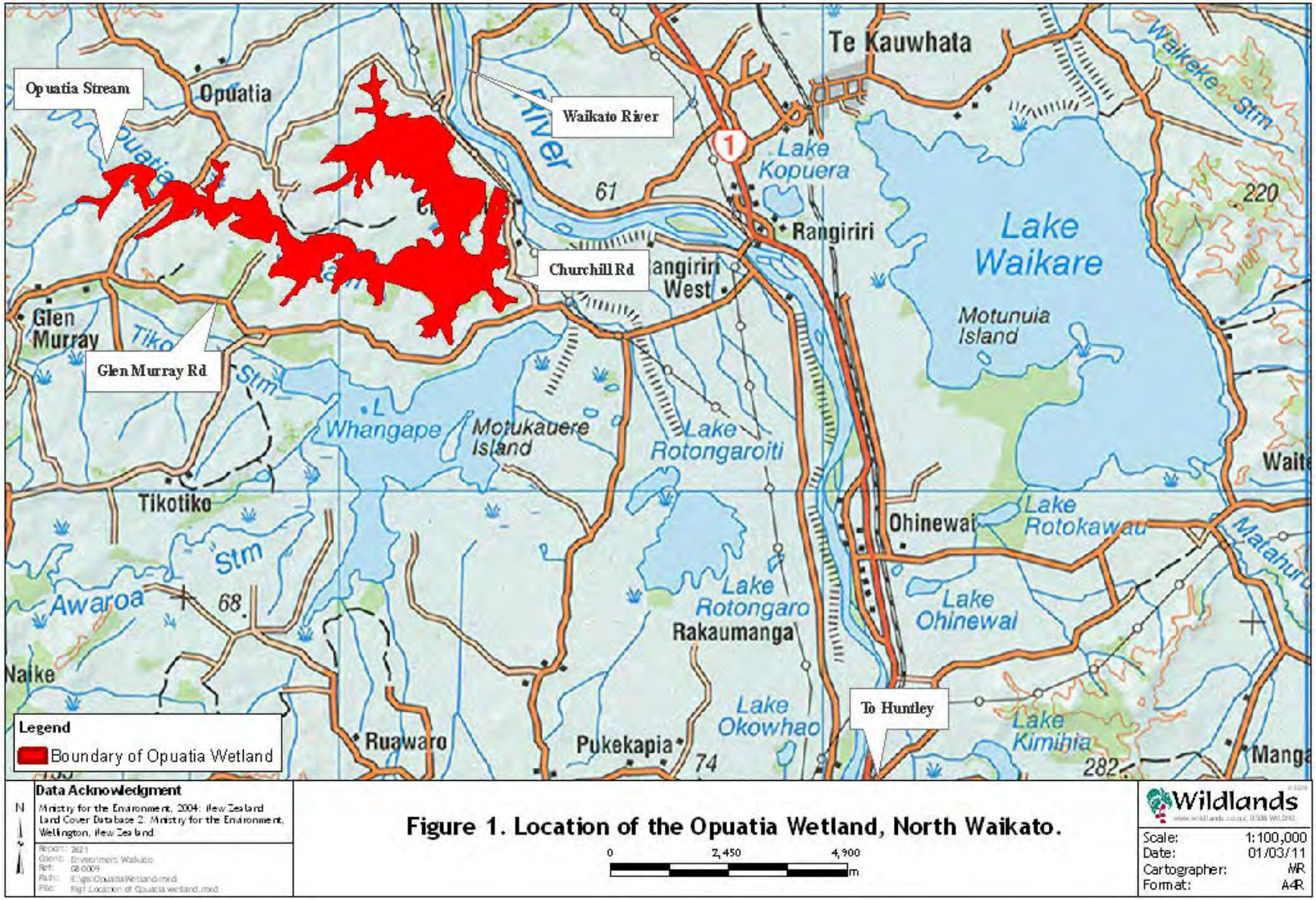


Figure 1. Location of the Opuatia Wetland, North Waikato.

1.2 Methodology

Existing information was compiled and evaluated. Walk-through field inspections were undertaken on 4 and 20 February 2011. All vegetation types were visited, however access was limited in the northern area due to the large number of dead willow in this area. During the walk through vegetation type boundaries were mapped on colour aerial photographs provided by WRC (scale 1:3,000, 2008) and were subsequently updated using more recent aerial photography (5 July 2009) from Google Maps NZ (www.maps.google.co.nz, accessed 20/2/2011). Vegetation types were described, and lists were compiled of vascular plants and birds. Pest plants within each vegetation type were identified.

2. BACKGROUND

In 2000 the Asset Management Group of the Waikato Regional Council was granted resource consent for flood protection works in the vicinity of Mercer in the Lower Waikato River catchment. The consent activities had significant adverse effects on wetland habitat. To mitigate these effects the consent holder was required to develop a restoration plan for Opuatia Wetland and to increase the duration of inundation over 60 ha of wetland.

The overall goal of the restoration plan was to '*restore the natural ecological processes within the peat bog and mineralised areas of the Opuatia Wetland and to enhance the diversity of wetland habitat for indigenous fauna*' (Barnes *et al.* 2001). Specific objectives for achieving this goal included the following:

- Restore a natural inundation regime to the mineralised wetland.
- Raise the minimum groundwater levels of the Opuatia peat bog to maintain and enhance a functioning peat bog ecosystem.
- Prevent stock access to the Opuatia peat bog.
- Undertake weed control activities in areas of high ecological value.
- Promote restorative plantings in areas of high priority.
- Continue with vertebrate pest control programmes within the wetland.
- Monitor changes to the wetland communities that occur following the above activities.

Over the past ten years a number of actions have been taken to achieve these objectives. Table 1 summarises the actions taken and subsequent outcomes.

3. MANAGEMENT OBJECTIVES

As discussed in the previous section, management goals and objectives were set for the entire Opuatia Wetland in 2001. These were reviewed with WRC and some modifications made to make these more specific to the WRC peat bog and to reflect progress made since the 2001 restoration plan.

Table 1: Actions taken to achieve management objectives in the 2001 Restoration Plan for Opuatia Wetland.

Goal	Date	Actions	Outcome
Restore a natural inundation regime to mineralized wetland.	2002/2003	Levee constructed along *c.*2 km of the true right bank of the Opuatia Stream to a minimum height of 5. 0 m RL. Installed two 900 mm diameter one way flapgated culverts (invert 4.2 m RL) at natural low points in the levee.	Flapgates consistently jammed open. This drained the area quicker than if they weren't there. Flapgates were consequently removed. Floods and holds water in the mineralized wetland but only when water level is above 5.0 m RL (40% of time between Dec 2002-Sep 2006*).
Raise the minimum groundwater levels of the Opuatia peat bog to maintain and enhance a functioning peat bog ecosystem.	2003-2005	Several studies by MSc students at the University of Waikato (Browne 2005, Thornburrow 2005, Fritz 2006) investigated aspects of the health and/or function of the peat bog at Opuatia Wetland.	Studies concluded that the peat bog generally had a high and stable water table indicative of a healthy wetland. Floods with a 15 yr return period inundate the bog with floodwater. This probably accounts for high soil pH levels recorded within the peat bog.
Prevent stock access to the Opuatia peat bog.	2006	Fence erected around the perimeter of the peat bog managed by WRC.	Stock impacts eliminated from wetland margin. Regeneration of native and exotic plant species.
Undertake weed control activities in areas of high ecological value.	2007	Grey willow on margins of peat bog managed by WRC aerial sprayed with herbicide (glyphosate).	Most grey willow killed with some off-target damage. However, a large number of grey willow saplings have since re-established.
	2008-2010	Repeat spraying of gorse along margins of peat bog managed by WRC.	Large amounts of gorse still persist.
Promote restorative plantings in areas of high priority.	2006-2009	WCEET funding enabled several hectares on the western margins of peat bog managed by WRC to be planted with appropriate species.	Canopy closure achieved over ~ 30% of the site. Few problematic weeds, some natural regeneration occurring at site.
Continue with vertebrate pest control programmes within the wetland.	Ongoing	Possums are controlled regularly throughout the wetland to prevent spread of TB.	n/a
Monitor changes to the wetland communities that occur following the above activities.	2003-2006	Vegetation and hydrological monitoring carried out in the Opuatia Wetland by WRC and the University of Waikato.	n/a
	2007	Additional vegetation plots set-up in the peat bog managed by WRC to monitor the effects of grey willow control.	

* Source: Data from WRC water level recorder at Opuatia Wetland.

The overall management goal is to '*restore the natural ecological processes within the **Waikato Regional Council** peat bog **and its margins** and to enhance the diversity of wetland habitat for indigenous fauna **and flora***'.

Specific objectives for achieving this goal included the following:

- Undertake weed control activities in areas of high ecological value.
- **Prevent incursions of new weeds that could have major adverse effects on areas of high ecological value.**
- Promote restorative and **buffer** plantings in areas of high priority.
- Extend current vertebrate pest control programmes to **control deer.**
- **Promote management that facilitates a stable hydrological regime.**

Monitor changes to the wetland communities that occur following the above activities.

4. DESCRIPTION

4.1 Location, legal description, and tenure

The area of peat bog managed by Waikato Regional Council (hereafter referred to as the WRC peat bog) is shown in Figure 2. While this area is referred to as 'peat bog' it also contains areas of fen and swamp on the margins. The legal description of the property is DP 22689.

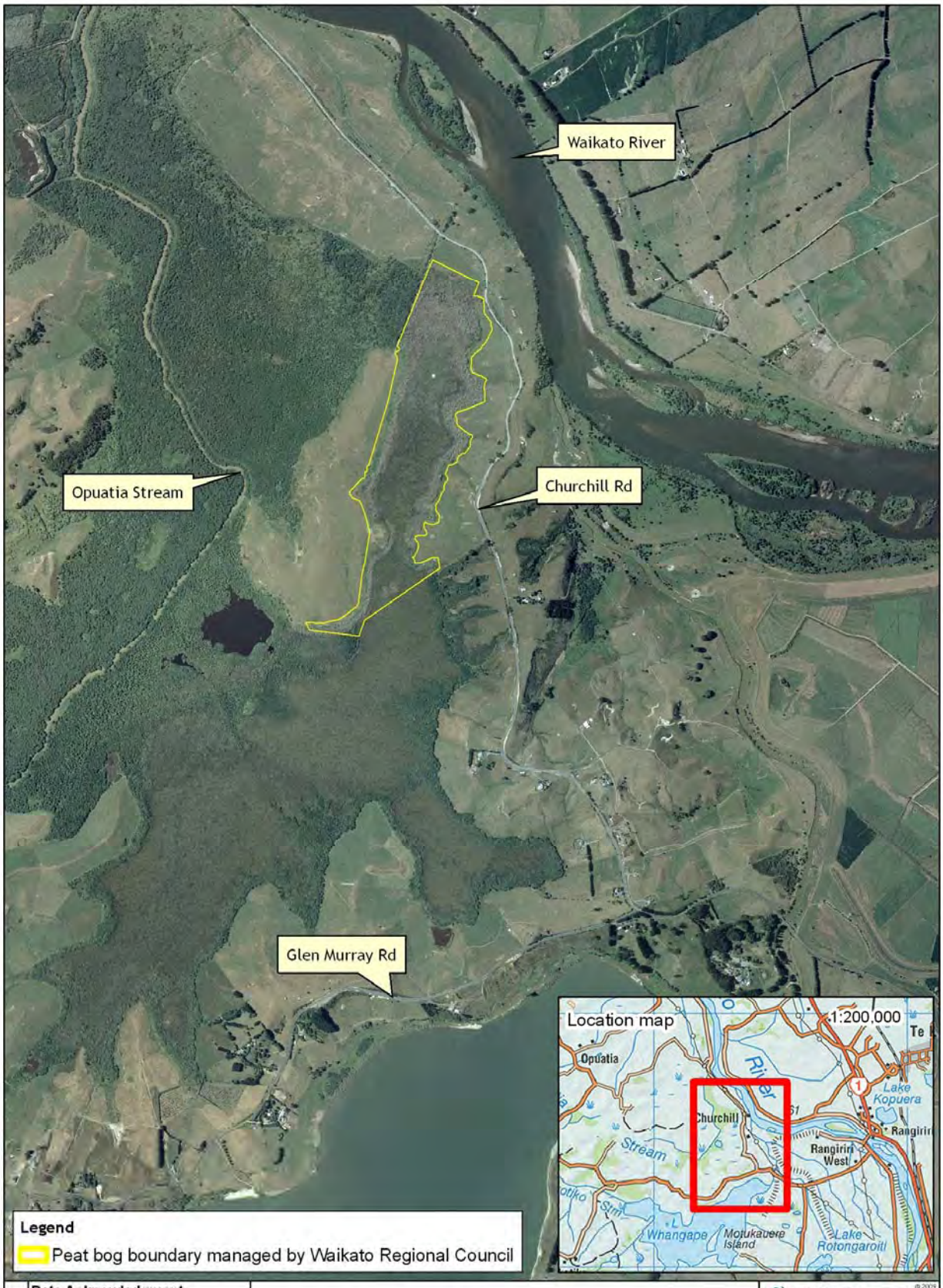
The land is Crown land, acquired under the Land Act 1948 for soil conservation and river control as part of the Lower Waikato-Waipa Control Scheme managed by WRC.

The high ground surrounding the WRC peat bog is developed farmland and is currently leased for grazing by a neighbouring landowner. This includes an 'island' of high ground to the west of the peat bog which is accessed by a causeway as shown in Figure 2. Culverts underneath the causeway provide a hydrological link between the WRC peat bog and an area of willow-dominated swamp on Government Purpose Reserve managed by the Department of Conservation (DOC). The southern margin of the WRC peat bog adjoins a more extensive area of privately owned peat bog and fen.

The area is best accessed by foot or 4WD from the causeway off Churchill Rd.

4.2 Climate

The Opuatia Wetland experiences warm summers and mild winters, with temperatures occasionally as low as 6°C in winter (Figure 3a). Average annual rainfall was 1,349 mm during the six year period a climate station was operating at Opuatia Wetland. Rainfall was highest in the winter months and lowest in late summer which reflects the longer term trends at the Mangatawhiri climate station (Figure 3b). Winds in the Lower Waikato Basin arise predominantly in the west/ south west and tend to be strongest in the spring (Cromarty and Scott 1996, Reeves *et al.* 2002).


Waikato River
Opuatia Stream
Churchill Rd
Glen Murray Rd
Location map
1:200,000
Opuatia
Churchill
Lake Kopuera
Rangiriri West
Whangape
Motukaivere Island
Lake Rotongaroiti
Legend
Peat bog boundary managed by Waikato Regional Council
Data Acknowledgment
Environment Waikato
Report: 2621
Client: Environment Waikato
Ref: 08 0009
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File: Fig2. Location of peat bog.mxd
Figure 2. Location of the area of peat bog managed by Waikato Regional Council within the Opuatia Wetland.
Wildlands
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Date: 01/03/11
Cartographer: MR
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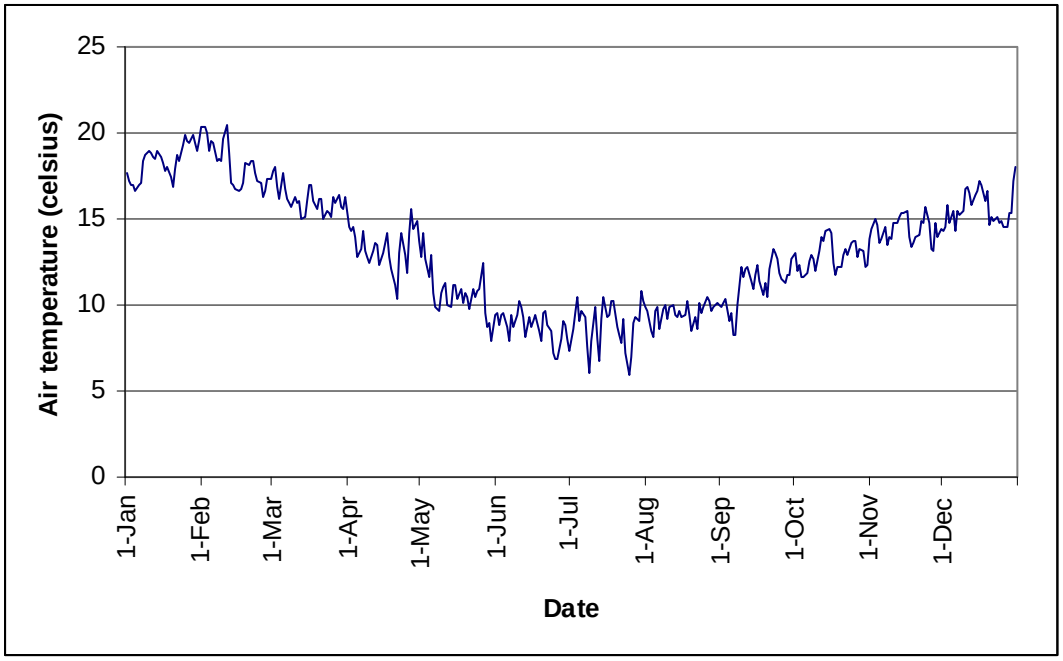


Figure 3a: Daily averages of air temperature at Opuatia Wetland from 1/1/2004-31/12/2010. *Source: Dave Campbell, University of Waikato.*

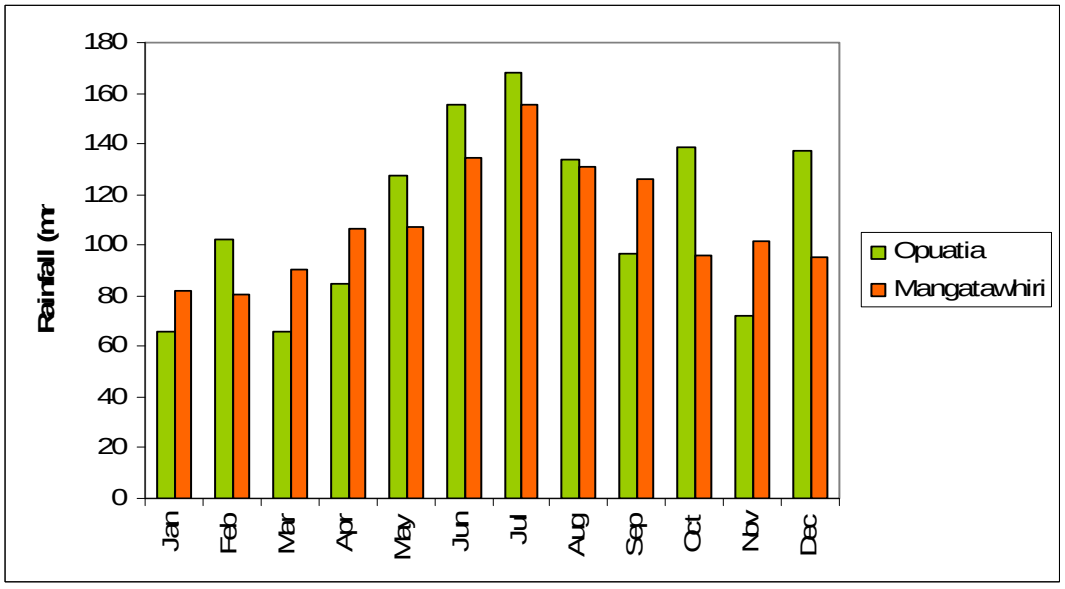


Figure 3b: Monthly average rainfall at Opuatia Wetland (2004-2009) and Mangatawhiri (1974-1993). *Source: Dave Campbell, University of Waikato; NIWA CliFlo..*

4.3 Geology and soils

The lower Waikato flood plain had its genesis during the Pleistocene when the Waikato River changed course to meet the sea at Port Waikato having previously flowed into the Firth of Thames. Following this was a period of extensive deposition of alluvium in the Hamilton Basin. After the Taupo eruption, floods of pumice material were carried down the river and deposited in the Lower Waikato River forming terraces that blocked off tributaries forming many of the wetlands, including Opuatia, that are found in the Lower Waikato Basin today (Cromarty and Scott 1995).

The soils at Opuatia Wetland are classified as Gley Soils and Organic Soils derived from alluvium and peat (Hewitt 1998). Peat thickness near the southern part of the WRC peat bog varies in thickness from <3 m near the margins to 10-12 m at the centre (Fritz 2006).

4.4 Hydrology

A hydrological monitoring network was set up in Opuatia Wetland in 2003 to gain an understanding of the hydrology of the wetland. A number of dip well sites and piezometers were located throughout the wetland and included two within the WRC peat bog.

Browne and Campbell (2005) found that Opuatia Wetland had a generally high and stable water table indicative of a healthy wetland. Water levels within the WRC peat bog were generally less than 10 cm below the surface, but during a 15 year flood event in 2004, water levels rose above the surface, possibly as high as 30 cm. This input of nutrient rich floodwater probably accounts for the high soil pH values (4.31-5.36) found at bog sites by Browne and Campbell (2005).

They also found the water level regime in the WRC peat bog differed from the remainder of the peat bog, suggesting some type of hydrological boundary exists between them. Figure 4 shows the average surface water contours within the Opuatia Wetland and the likely direction of water movement. The highest water surface contours in the WRC peat bog occur close to the narrowest section with water moving away from this area towards the north and south. Browne and Campbell (2005) and Fritz (2006) also found that there was a steep water gradient towards the causeway.

4.5 Birds

A limited number of birds were recorded during the field survey (Table 2). The low diversity may be due in part to the season and time of day (middle of the day) as these can affect conspicuousness. The removal of the willow canopy will have removed opportunity for some species by reducing cover and/or perching, nesting and feeding habitat, particularly for insectivorous passerines.

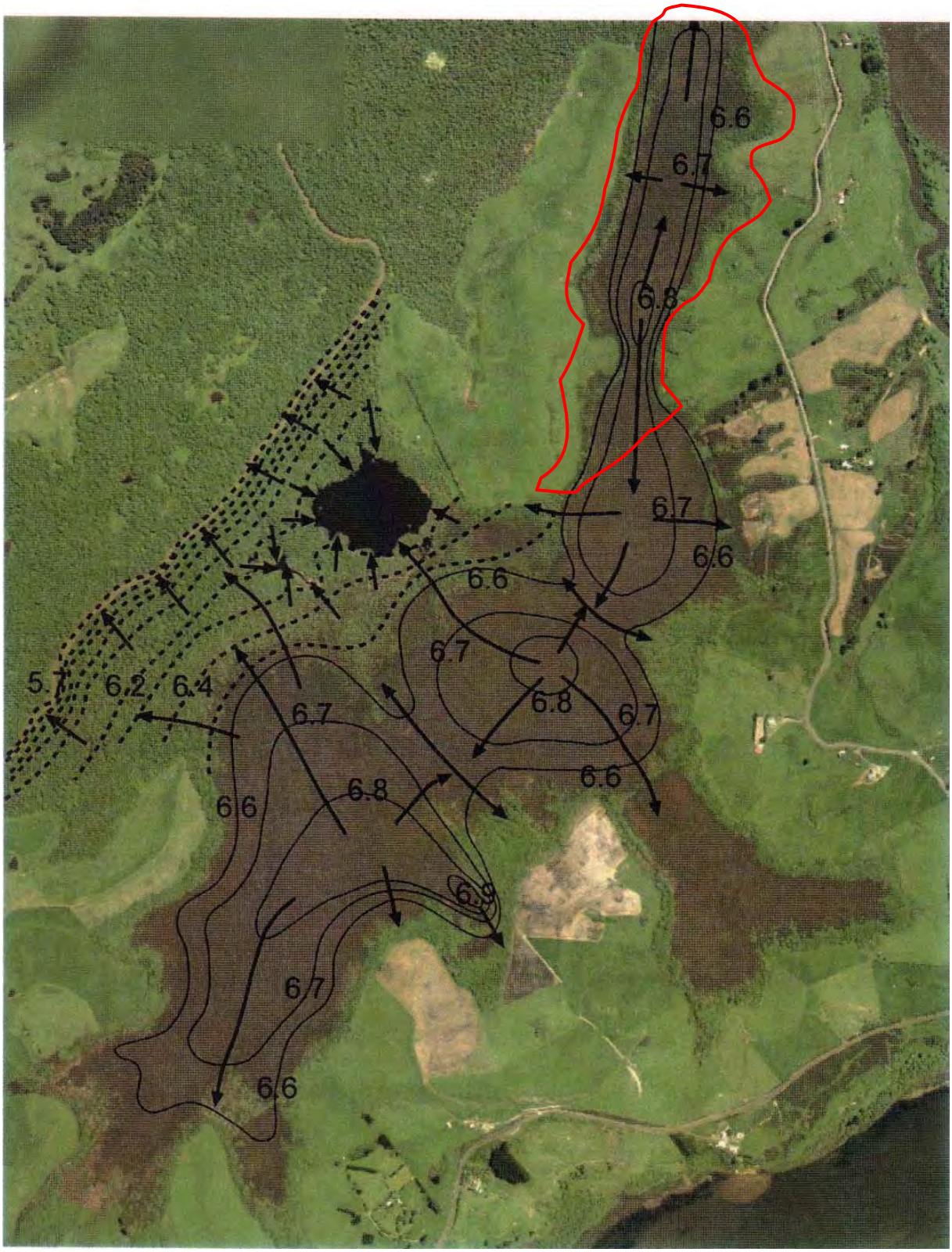


Figure 4: Average water level surface contours at 0.1 m ASL intervals and flow directions for 1 June - 1 September 2004. Dashed contours are inferred. The WRC peat bog is shown in red. *From Browne and Campbell (2005).*

Table 2: Birds recorded at WRC Peat Bog at Opuatia on 4 and 20 February 2011.

Recorded in the Wetland Itself	Species	Notes
Bowdleria punctata	North Island fernbird	Single bird sighted on margins of manuka scrubland.
Emberiza citrinella	yellowhammer[1]	Conspicuous in all areas traversed.
Fringilla coelebs	chaffinch[1]	Several heard in manuka scrubland.
Gerygone igata	grey warbler	One heard in grey willow forest at northern end of wetland.
Hirundo tahitica neoxena	welcome swallow	Several birds seen or heard in central and southern parts of wetland.
Phasianus colchicus	pheasant[1]	One bird observed in planted area.
Porphyrio porphyrio melanotus	pukeko	One bird observed in grey willow forest at northern end of wetland.
Recorded in Close Vicinity of the Wetland		
Anas platyrhynchos	mallard[1]	Present on nearby pond.
Branta canadensis	Canada goose[1]	100+ on pasture nearby.
Circus approximans	Australasian harrier	One seen flying over.
Phalacrocorax melanoleucos brevirostris	little shag	Two seen flying over.

[1] Introduced species.

The most conspicuous species encountered within the wetland itself during the field survey was yellowhammer followed by welcome swallow, both of which were observed throughout. North Island fernbird (*Bowdleria punctata*), (classified as "At Risk-Declining" by Miskelly *et al.* (2008) was encountered on the margins of the wire rushland and manuka scrubland habitat during the second visit, but this was confined to one sighting. It is somewhat surprising more were not encountered given the amount of suitable habitat available.

Of the birds incidentally observed within the near vicinity, Australasian harrier and mallard are the species most likely to utilise the wetland itself, but in low numbers, habitat for the latter largely being restricted to areas of open water (when available) at the northern end of the wetland.

Australasian bittern (*Botaurus poiciloptilus*), a species classified as "Threatened-Nationally Endangered" might utilise mineralised or semi-mineralised parts of the wetland when shallow open water is present from time to time, but is very unlikely to be more than an occasional visitor. One or more pairs of spotless crake (*Porzana tabuensis*), (classified as "At Risk-Relict") could potentially be resident within the northern part of the wetland where shallow water is a perennial feature of the area.

4.6 Flora

One hundred and thirty-seven vascular species were recorded during the survey, and these are listed in Appendix 1. The fens were particularly rich in indigenous species, containing a wide range of sedges. No threatened species (as per de Lange *et al.*

2009) were recorded during the course of the survey. It is possible that several threatened orchids (e.g. *Pterostylis micromega, P. paludosa*) may occur in the WRC peat bog as there is suitable habitat and they have been found within 100 m by Department of Conservation staff (DOC internal memo, December 2007). Our survey was conducted too late in summer for these orchids to be detected.

4.7 Vegetation

Thirteen vegetation types were mapped during the field survey (Figure 5). These have been grouped according to wetland type and are described below:

Swamp Vegetation Types

Swamps are defined as wetlands that receive nutrient and sediment from surface runoff, and groundwater from adjacent land. They usually have a combination of mineral and peat substrates with a water table that fluctuates but is often above the ground surface (Johnson and Gerbeaux 2004).

1. Alder/manuka-grey willow forest

   Alder (*Alnus glutinosa*) dominates two small areas on the edge of the causeway. Both manuka and tall saplings of grey willow also occur in the canopy. The understorey is mainly comprised of indigenous species including cabbage tree (*Cordyline australis*), swamp coprosma (*Coprosma tenuicaulis*), flax and *Carex virgata*. Reed sweetgrass (*Glyceria maxima*), an invasive introduced grass, is common next to the causeway.

2. Reed sweetgrass grassland

   This grassland occurs on the wet margins of the wetland in the northern half of the wetland. It is mainly comprised of reed sweetgrass, but other species are present including indigenous sedges (*Carex gaudichaudiana, C. subdola*), swamp buttercup (*Ranunculus flammula*), and the introduced grasses, reed canary grass (*Phalaris arundinacea*) and Yorkshire fog (*Holcus lanatus*).

3. Indigenous and exotic herbaceous wetland vegetation

   The most common swamp vegetation type is a mix of indigenous and exotic species. In the wettest areas, exotic milfoil (*Myriophyllum aquaticum*), swamp buttercup, and the indigenous persicaria (*Persicaria decipiens*) typically dominate the northern and western margins. On the eastern margin an indigenous milfoil (*Myriophyllum propinquum*), bur reed (*Sparganium subglobosum*), and the indigenous sedges *Eleocharis acuta* and *Baumea arthrophylla* are more common. In the less wet fringes, patches of *Carex subdola, C. gaudichaudiana* and gypsywort (*Lycopus europeaus*) were recorded along with a diverse range of introduced herbs, grasses and rushes, most notably lotus (*Lotus pedunculatus*), creeping bent (*Agrostis stolonifera*), soft rush (*Juncus effusus* var. *effusus*) and sharp-fruited rush (*Juncus acuminatus*).

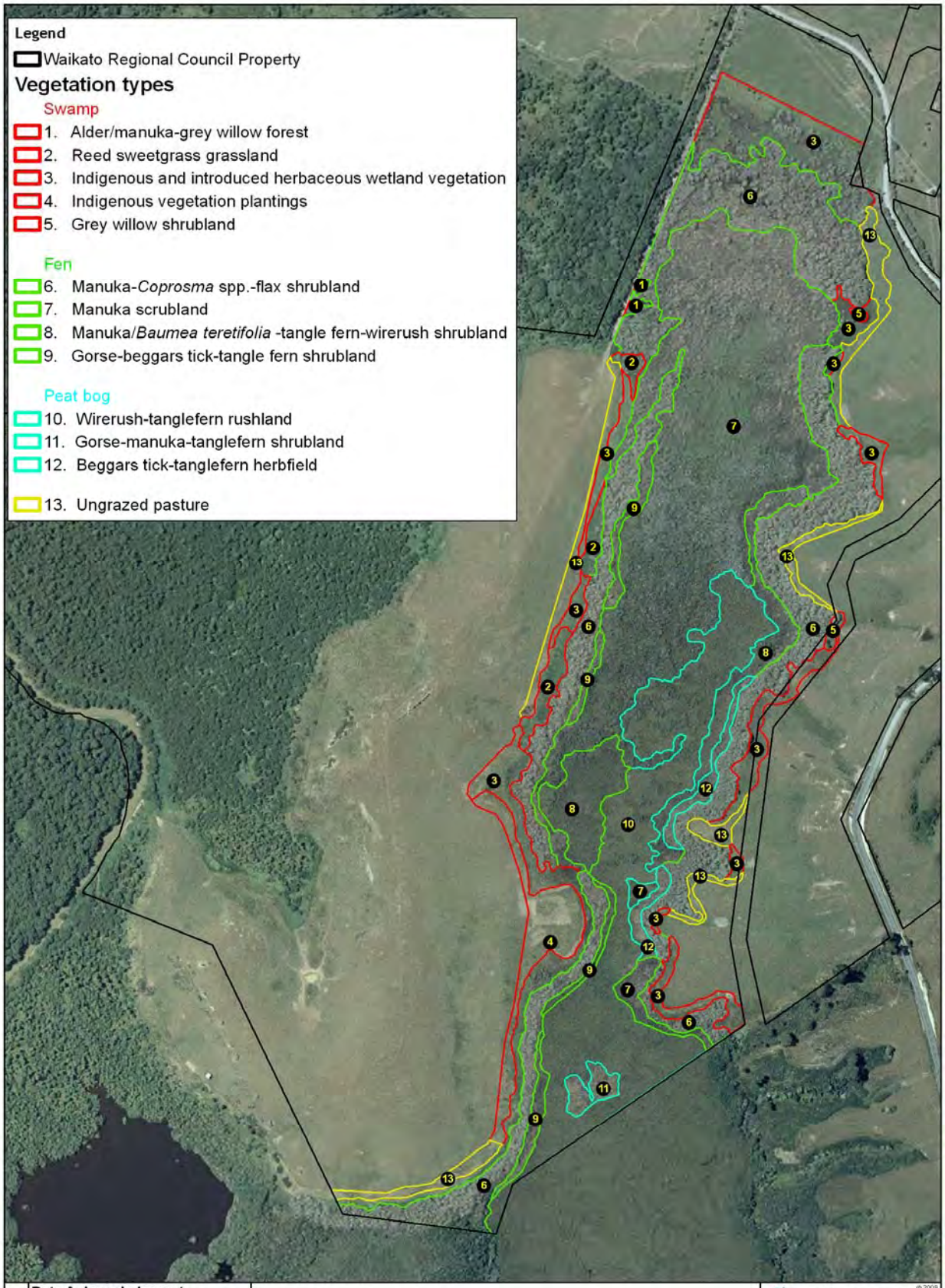


Figure 5. Vegetation types at the Waikato Regional Council managed peat bog at Opuatia Wetland.

There are a number of pest plants present in this vegetation type. They include yellow flag iris (*Iris pseudacorus*), reed sweetgrass, reed canary grass and alder. Most of the tall crack willow (*Salix fragilis*) and grey willow are dead, but some isolated individuals are regenerating, and grey willow saplings are common.

4. Indigenous vegetation plantings

In 2006, WRC, with funding from the Waikato Catchment Ecological Enhancement Trust, began a three-year project to revegetate some of the wetland margins on the south-western side of the wetland. A range of species were planted and these are listed below:

cabbage tree
Carex sp. (no seed heads to identify)
Carex virgata
Coprosma ×*cunninghamii*
Coprosma rhamnoides
flax (*Phormium tenax*)
Gahnia sp. (no seed heads)
kahikatea
karamu (*Coprosma robusta*)
manuka
mingimingi (*Coprosma propinquum*)
poataniwha (*Melicope simplex*)
pokaka (*Elaeocarpus hookerianus*)
swamp astelia (*Astelia grandis*)
swamp coprosma (*Coprosma tenuicaulis*)
matai (*Prumnopitys taxifolia*)

Most of the plantings are well established and canopy closure has occurred in some parts of the re-vegetation area. The species that have grown the least are kahikatea and matai. The area is mostly absent of pest plants with the exception of several grey willow saplings that were observed within it.

5. Grey willow shrubland

Aerial application of herbicide to control willow in the wetland in 2007 was largely successful. However there are some small areas on the eastern margin where clusters of grey willow have regenerated. These areas have a dense grey willow canopy with an understorey of mainly introduced herbs and grasses.

Fen Vegetation Types

Fens are wetlands with a predominantly peat substrate that receive some nutrient inputs. The water table is usually close to, or just below the peat surface, and relatively constant (Johnson and Gerbeaux 2004).

6. Manuka-*Coprosma* spp.-flax shrubland

Before the willow control operation in 2007, grey willow dominated the canopy of this vegetation type. Grey willow has been reduced to <1% of the canopy. The canopy is now dominated by manuka, swamp coprosma, mingimingi and flax, with the occasional emergent cabbage tree. The understorey is comprised of indigenous sedges (e.g. *Baumea tenax, B. rubiginosa, Tetraria capillaris, Carex virgata*), and the fern, swamp kiokio (*Blechnum novae-zelandiae*). Stands of raupo (*Typha orientalis*) occur mainly on the fringes, often at the base of a hillslope seep where nutrient inputs are typically highest.

Removal of the grey willow canopy allowed a lot more light into this vegetation type. As a result a large number of saplings are present. A large proportion of these are grey willow, with lesser amounts of manuka, swamp coprosma and alder. Other pest plants common in this vegetation type, particularly in the north of the wetland, include yellow flag iris, reed sweetgrass, and reed canary grass. The invasive royal fern (*Osmunda regalis*) was found in low numbers at several locations along the eastern margin.

7. Manuka scrubland

Manuka dominates the canopy of this vegetation type. Before the willow control operation the more northern areas of this vegetation type had large amounts of grey willow in the canopy which has now been killed.

The understorey is comprised of tall tangle fern (*Gleichenia dicarpa*), *Baumea teretifolia*, and swamp kiokio with very occasional mounds of *Sphagnum* moss. Swamp coprosma, mingimingi, *Dianella nigra* and gorse (*Ulex europaeus*) are present on the fringes. Wire rush (*Empodisma minus*) is common where the tall manuka canopy has become sparser on the edges of the peat bog.

Deer tracks were observed widely within this vegetation type. Patches of forked sundew (*Drosera binata*), and the native ground cover *Nertera scapanioides* are present along these tracks.

8. Manuka-*Baumea teretifolia*-tangle fern-wire rush shrubland

This vegetation type is similar in composition to manuka shrubland, the difference being that manuka is of lesser height, and *Baumea teretifolia*, tangle fern and wire rush are more common in the canopy.

9. Gorse-beggars' tick-tangle fern shrubland

The willow control operation appears to have induced several new vegetation types on the inner wetland fringe of the control area. On the western margin, this vegetation type is dominated by the pest plants gorse and beggars' tick, although the indigenous tangle fern was also common. Several other annual or short lived perennial species that require open habitat aree also present including Australian fireweed (*Senecio bipinnatisectus*), American fireweed (*Erechtites hieraciifolia*), fleabane (*Conyza sumatrensis*) and *Juncus planifolius*.

Peat Bog Vegetation Types

Peat bogs are typically nutrient poor, poorly aerated, and very acidic, with the water table close to, or just above the ground surface (Johnson and Gerbeaux 2004). Water supply is typically from precipitation only, but at Opuatia the bogs appear to be very occasionally (approximately every 15 years) inundated with floodwaters when flooding in the Waikato River backs up into the Opuatia Stream. As a consequence these bogs are less acidic than is normally the case.

10. Wire rush-tangle fern rushland

This, the main vegetation type occupying the peat bog, is dominated by wire rush and tangle fern, and occurrs in the southern half of the WRC peat bog. Individual culms of *Baumea teretifolia* are common. Near the southern boundary, short gorse plants are scattered amongst the wire rush and tangle fern. Very occasional mounds of *Sphagnum* moss were observed with some appearing a pale orange indicating they had been desiccated. Numerous tracks and some bedding sites created by deer were also found within this vegetation type. While most species had been trampled along the tracks and within the bedding sites, forked sundew, *Nertera scapanioides,* the orchid *Microtis unifolia,* and several types of moss were present.

11. Gorse-manuka-tangle fern shrubland

Near the southern boundary amidst the wire rush and tangle fern was a small area that had been dominated by grey willow before the 2007 willow control operation. This area is now dominated by gorse, manuka and tangle fern. Grey willow seedlings are present along with other opportunistic weeds such as Australian and American fireweed.

12. Beggars' tick-tangle fern herbfield

Like the 'gorse-beggars' tick-tangle fern shrubland' vegetation type, this vegetation type appears to have been induced by willow control. It occurs along the eastern margin in areas where the understorey formerly comprised wire rush and tangle fern. In some places the tangle fern has regenerated (probably from rhizomes), but most of the wire rush has not, and lies undecomposed on the bog surface. Beggars' tick, an introduced annual, frequently forms dense patches amongst the dead wire rush. Manuka saplings and small clumps of *Baumea teretifolia* occur in low densities. Unlike the western margin, gorse is absent.

Wetland Margin

13. Ungrazed pasture

A thin margin of ungrazed pasture occurs between the wetland and the fence, erected by WRC in 2006. This area remains dry most of the year. It is dominated by pasture grasses and annual herbs such as sweet vernal (*Anthoxanthum odoratum*), rye grass (*Lolium perenne*), brown-top (*Agrostis capillaris*), lotus, and white clover (*Trifolium repens*).

5. MANAGEMENT ISSUES

5.1 Hydrology

Hydrology is generally considered to be the most important factor maintaining natural ecological processes within wetlands (Mitsch and Gosselink 2000). The eco-hydrological study conducted by Browne and Campbell (2005), indicated that at the time of their work, the Opuatia Wetland had a generally high and stable water table

indicative of a healthy wetland although there was a steep water gradient at the causeway, with water elevations falling approximately 0.8 m over the 800 m distance between the causeway and the closest piezometer. It should be noted that water levels were only monitored for an 18 month period, and during a year when a 15 year return flood event occurred during the summer.

While Browne and Campbell's (2005) study indicated a stable hydrology at Opuatia Wetland, the extent and age of gorse in the WRC peat bog suggests otherwise for at least this part of the wetland. While gorse can thrive in areas with a high water table it does not tolerate being permanently waterlogged (Zabkiewicz 1976). It is, therefore, possible that parts of the WRC peat bog are seasonally dry.

In March 2007, the causeway at the northern end of the WRC peat bog was upgraded, and several additional culverts were put underneath the causeway to prevent it from flooding during winter (water direction is from the WRC peat bog into the DOC reserve). While these culverts were set approximately 300 mm higher than the existing larger culvert, reed sweetgrass blocks the downside of the old culvert, resulting in water levels sitting 500 mm higher than the invert of the old culvert (Michelle Hodges pers. comm.). This will have increased the water table near the causeway, and it is likely that water levels fluctuate over a greater range in this area than was previously the case prior to the causeway upgrade.

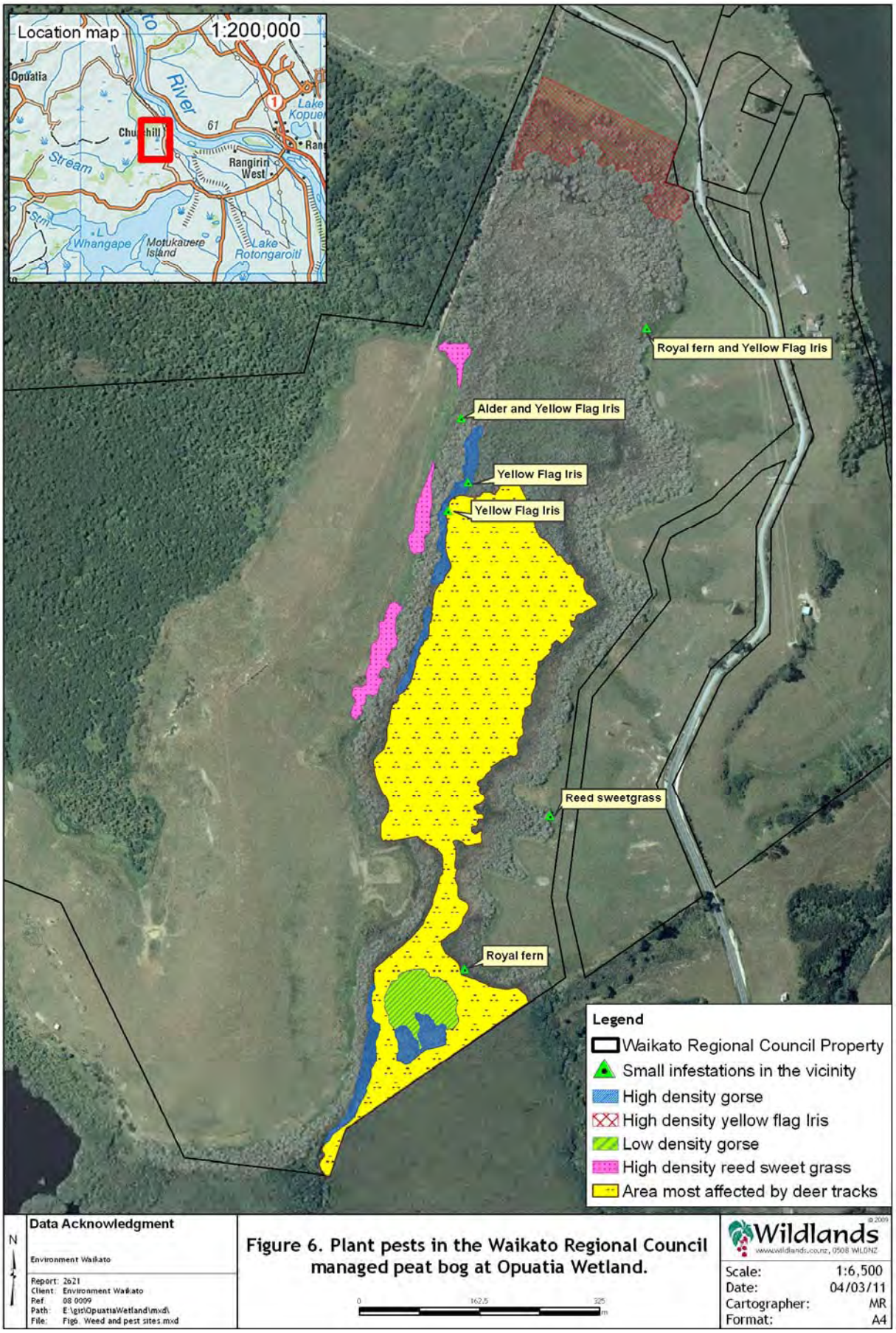
5.2 Vertebrate pests

A range of vertebrate pests (e.g. possum, hedgehogs, Norway rat, ship rats, feral cats, and mustelids) are likely to be present in Opuatia Wetland (Barnes *et al*. 2001). Many of these predators could have a significant effect on native fauna, particularly ground nesting birds such as marsh crake, brown teal and banded rail. To date, only possum have been controlled within the Opuatia Wetland as part of a Priority Pest Control Area (PPCA) programme. This programme aims to reduce possum numbers to protect and enhance biodiversity, enhance farm production, and maintain the gains of previous or existing possum control (Environment Waikato 2010).

It was evident during the field survey that red deer (*Cervus elaphus scoticus*) are impacting on the vegetation of the WRC peat bog. An extensive network of deer tracks through the manuka shrubland and wire rush-tangle fern rushland was observed. There were also a number of bedding sites near the southern edge of the manuka shrubland. While deer can open up habitat for some indigenous species, particularly orchids, sundews, and clubmosses, the amount of tracking through a narrow piece of wetland has resulted in a significant portion of the peat bog being trampled. It is also likely they are feeding on more palatable species in the wetland including orchids, cabbage tree and some ferns.

5.3 Plant pests

The majority of the 71 introduced species listed in Appendix 1 are not likely to have an impact on the ecological integrity of the WRC peat bog. However, at least eight of the species listed below, are a serious threat, or have the potential to be such, to the long term persistence of indigenous wetland vegetation. Figure 6 shows the location and density of some of these plant pests.


Location map
1:200,000
Opuatia
River
Stream
Rangiriri West
Whangape
Motukaurere Island
Lake Rotongaroiti
Royal fern and Yellow Flag Iris
Alder and Yellow Flag Iris
Yellow Flag Iris
Yellow Flag Iris
Reed sweetgrass
Royal fern
Legend
Waikato Regional Council Property
Small infestations in the vicinity
High density gorse
High density yellow flag Iris
Low density gorse
High density reed sweet grass
Area most affected by deer tracks
Data Acknowledgment
Environment Waikato
Report: 2621
Client: Environment Waikato
Ref: 08 0009
Path: E:\gis\OpuatiaWetland\mxd\
File: Figs. Weed and pest sites.mxd
Figure 6. Plant pests in the Waikato Regional Council managed peat bog at Opuatia Wetland.
Wildlands
Scale: 1:6,500
Date: 04/03/11
Cartographer: MR
Format: A4

Grey willow (*Salix cinerea*)

Grey willow has been present in the Opuatia Wetland since at least 1942 and has invaded the majority of fen within the wetland (Browne 2005). It is considered a serious threat to swamps and fens as its height enables it to displace indigenous vegetation. It does not tolerate the acidic, nutrient poor conditions found in most bogs, and does not appear to be invading the peat bog vegetation at Opuatia Wetland.

Prior to willow control in 2007, the swamp and fen margins of the WRC peat bog were largely dominated by grey willow in the canopy, with an understorey that was mostly indigenous. The aerial application of herbicide (glyphosate) killed the majority of grey willow, with the exception of isolated individuals and some small clusters on the eastern margin. The reduction in canopy cover in these areas has increased light levels which has allowed a number of new plants of both introduced and indigenous species to establish. This includes grey willow and we estimate that several thousand saplings (1-3 m tall) are now present, mainly in the 'manuka-*Coprosma* spp.-flax shrubland' vegetation type (Figure 5). Fencing the margin has also allowed grey willow to establish in the swamp vegetation types, as cattle no longer graze the seedlings and small saplings.

Crack willow (*Salix fragilis*)

Crack willow has probably been present in the Opuatia Wetland a lot longer than grey willow, but would not have been common in the WRC peat bog as suitable habitat there is limited. Prior to willow control in 2007, it was reasonably common near the causeway and the northern boundary. During this survey it was apparent that a significant portion of the sprayed crack willow had regenerated.

Alder (*Alnus glutinosa*)

Alder was present in several locations within the wetland. Several large clusters occurred along the causeway but tall individuals and saplings were also found further south (Figure 6). Alder thrives in wet soils and is commonly found in riparian floodplains along the lower Waikato River. It can grow to a height of >20 m and produces thousands of water dispersed seeds. It does not compete well in shady conditions. Alder appears to have benefited from willow control as many small saplings were encountered during the field survey in the 'manuka-*Coprosma* spp.-flax shrubland' vegetation type.

Reed sweetgrass (*Glyceria maxima*)

Reed sweetgrass occurs mainly on the swamp margins of the wetland in the northern half of the wetland although patches of reed sweet grass were also found in other locations (Figure 6). In several places it has formed dense stands displacing most other vegetation. It does not tolerate shading, and like alder appears to have benefited from willow control. Many small patches of reed sweetgrass were encountered during the field survey in the 'manuka-*Coprosma* spp.-flax shrubland' vegetation type. It will also have thrived since the area was fenced and stock excluded.

Reed canary grass (*Phalaris arundinacea*)

Reed canary grass occupies a similar habitat to reed sweetgrass and will also smother indigenous vegetation. Its occurrence is much patchier than reed sweetgrass, and it is more common in the southern part of the wetland than reed sweetgrass. It will also have benefited from willow control and fencing.

Yellow flag iris (*Iris pseudacorus*)

Like alder, yellow flag iris is mainly confined to the northern half of the wetland but appears to be spreading southward along the western margin. It was not recorded in a comprehensive species list for Opuatia Wetland updated in 2006 by de Lange, so is most likely a recent arrival. Yellow flag iris can form dense monospecific stands that displace wetland vegetation. It can tolerate water depths up to 0.3 m and will grow in fens and under partial shade (www.na.fs.fed.us/fhp/invasive_plants/weeds/**yellow-iris**.pdf, accessed 8/2/2011). There are some large patches of yellow flag iris in the northern part of the wetland, but it hasn't yet formed the mono-specific stands common in floodplain wetlands along the lower Waikato River.

Gorse (*Ulex europaeus*)

Gorse is most common in the southern and western parts of the wetland although small patches do occur in ungrazed pasture along the eastern margin. Gorse is considered New Zealand's worst agricultural weed (Roy *et al*. 2004) and is considered an ecological indicator of over drained peat (Thompson and Greenwood, 1997). It often persists in areas that are seasonally wet, but does not tolerate being permanently waterlogged (Keith Thompson pers. comm.).

Gorse occupies hillsides surrounding the wetland and a large stand of gorse occurs within the wetland itself, south of the WRC peat bog (Browne 2005). It was present in the WRC peat bog prior to willow control but has substantially increased its cover since then (Michelle Hodges pers. comm.). It can seed profusely following non-selective spraying (www.weedbusters.co.nz/weed_info/detail.asp?WeedID=89, accessed 3/3/2011), and appears to have done so along the edges of the peat bog on the western side of the wetland and on the southern boundary (Figure 5), following willow control in 2007. Despite ongoing control of gorse in the wetland, it continues to persist and is a potential threat to the re-establishment of indigenous vegetation on the edges of the peat bog. It also occurs at low densities in the peat bog.

Royal fern (*Osmunda regalis*)

Royal fern is a perennial fern that can reach a height of 2 m. It is one of the few introduced plant species that can colonise peat areas and is now common throughout fens in the Waikato Region. In the WRC peat bog it was seen in only two places (Figure 6), but it has the potential to spread throughout the fen vegetation types. In other wetlands in the Waikato Region where willow control or other disturbance has taken place, it has formed a dense understorey (up to 100% cover) beneath manuka and grey willow.

5.4 Nutrient enrichment

Wetlands are very sensitive to nutrient enrichment, and it is second only to hydrological disturbance as a cause of loss of natural character (Sorrell 2010). While often the most difficult aspect to manage, if not addressed it usually leads to excessive growth of weeds, rapid vegetation succession and poor habitat for aquatic fauna.

Levels of nutrients have been analysed for Opuatia Wetland by Browne and Campbell (2005) and are summarised and compared with other New Zealand wetlands in Table 3. While none of the sampling sites were within the WRC peat bog, several sites were within 200 m of the southern boundary.

Table 3: A comparison of mean and range (in brackets) of soil parameters for wetlands sampled in New Zealand and Opuatia Wetland. *From Browne and Campbell (2005).*

	NZ bogs (6 sites)	NZ swamps (17 sites)	Opuatia bogs and fens (n=22)	Opuatia swamps (n=6)
Soil pH	4.0 (3.7-4.4)	5.2 (4.1-5.9)	4.99 (4.31-5.36)	5.05 (4.81-5.39)
Total Carbon*	92.7 (24.1-239.8)	39.8 (5.2-100.6)	33.3 (24.2-43.3)	39.8 (29.8-47.4)
Total Nitrogen*	0.82 (0.02-1.83)	2.12 (1.15-3.24)	1.35 (0.69-1.98)	2.39 (1.72-2.78)
Total Phosphorus*	0.08 (0.01-0.20)	0.28 (0.15-0.59)	0.08 (0.03-0.13)	0.26 (0.18-0.33)
C:N	48.5 (35.9-79.7)	18.0 (14.2-30.6)	26.4 (17-49)	16.7 (14-19)
C:P	1904 (533-4221)	163 (45-435)	507.1 (236.9-1041.8)	161.35 (116.3-212.7)
N:P	39.0 (20.6-81.6)	9.1 (4.0-20.6)	18.79 (13.7-27.3)	9.54 (8.34-11.72)

* units of mg cm^{-3}

The above table shows that the soil pH for bogs and fens in Opuatia Wetland were much higher than for other New Zealand bog sites. As discussed in Section 5.1, this is probably a result of occasional flood events that cover the entire Opuatia Wetland. Total nitrogen is generally higher than the averages for other New Zealand bogs and swamps although within the overall range. These results indicate that nutrient enrichment is occurring within the Opuatia Wetland.

6. RESTORATION AND IMPLEMENTATION PLAN

6.1 Hydrology

Two options are presented for addressing management of the hydrology at the WRC peat bog.

Option 1 - Further Investigation

Further investigation into the hydrology of the WRC peat bog could be undertaken to clarify issues discussed in Section 5.1. It is likely that the causeway is having some effect on water levels in the adjacent vegetation communities, but it is not known to what extent water levels are affected and how far these effects penetrate into the wetland. Piezometers were set up in 2006/07 in Opuatia Wetland as part of a PhD

study by Anthony Keen, but the data was never retrieved as the study was abandoned (Keith Thompson pers. comm.). It could be worthwhile retrieving the two-year data set as it may elucidate effects of the causeway upgrade on the hydrology, depending on the location of the piezometers.

Option 2 - Remove Causeway Culverts

A precautionary approach could be taken and all culverts removed from the causeway. However there are significant costs associated with this option. Without culverts the causeway would periodically be flooded which would require more frequent maintenance of the causeway, and/or there could be impacts on access to, and use of, the pastureland at its southern end.

6.2 Vertebrate pests

In addition to ongoing possum control, it is recommended that red deer are controlled within the Opuatia Wetland. A joint agency approach with the Department of Conservation is recommended as they manage the adjoining reserve and are experienced in controlling deer in other wetlands in the Waikato region. Initial discussions with DOC Waikato Area Office indicate they would support a joint approach (Dion Patterson pers. comm.).

It is also worth considering mustelid control within the wetland to enhance native bird populations. Before implementing a programme we suggest laying out tracking tunnels to gain some understanding of the likely densities of mustelids within the WRC peat bog. Laying out tracing tunnels does not require too much effort and will help guide the development of an appropriate control programme (see King 2004 for further information).

6.3 Plant pests

The greatest challenge in achieving management objectives for the WRC peat bog is to minimise the impact of plant pests on indigenous vegetation. Eradication of pest plants is unlikely to be attainable for most pest plants within the WRC peat bog due to their prevalence within the catchment. It will also be difficult to prevent re-invasion of plant pests as killing vegetation usually creates conditions that favour re-invasion or the invasion of other pest plants. For these reasons we recommend a staged, adaptive management approach to weed control. This will involve trialling weed control in high priority areas then monitoring the effectiveness and re-establishment of vegetation within the area, before extending control operations to other areas. We recommend this approach for all plant pests except royal fern. As royal fern is known from only several locations it may still be possible to prevent royal fern from spreading within the WRC peat bog. It is recommended that all known occurrences of royal fern (Figure 6) are controlled.

Priority areas for plant pest control are depicted in Figure 7. These are based on botanical conservation values, size of area, urgency/threats (including those imposed by seed or vegetative sources in adjacent areas), age and density of infestations (Table 4).

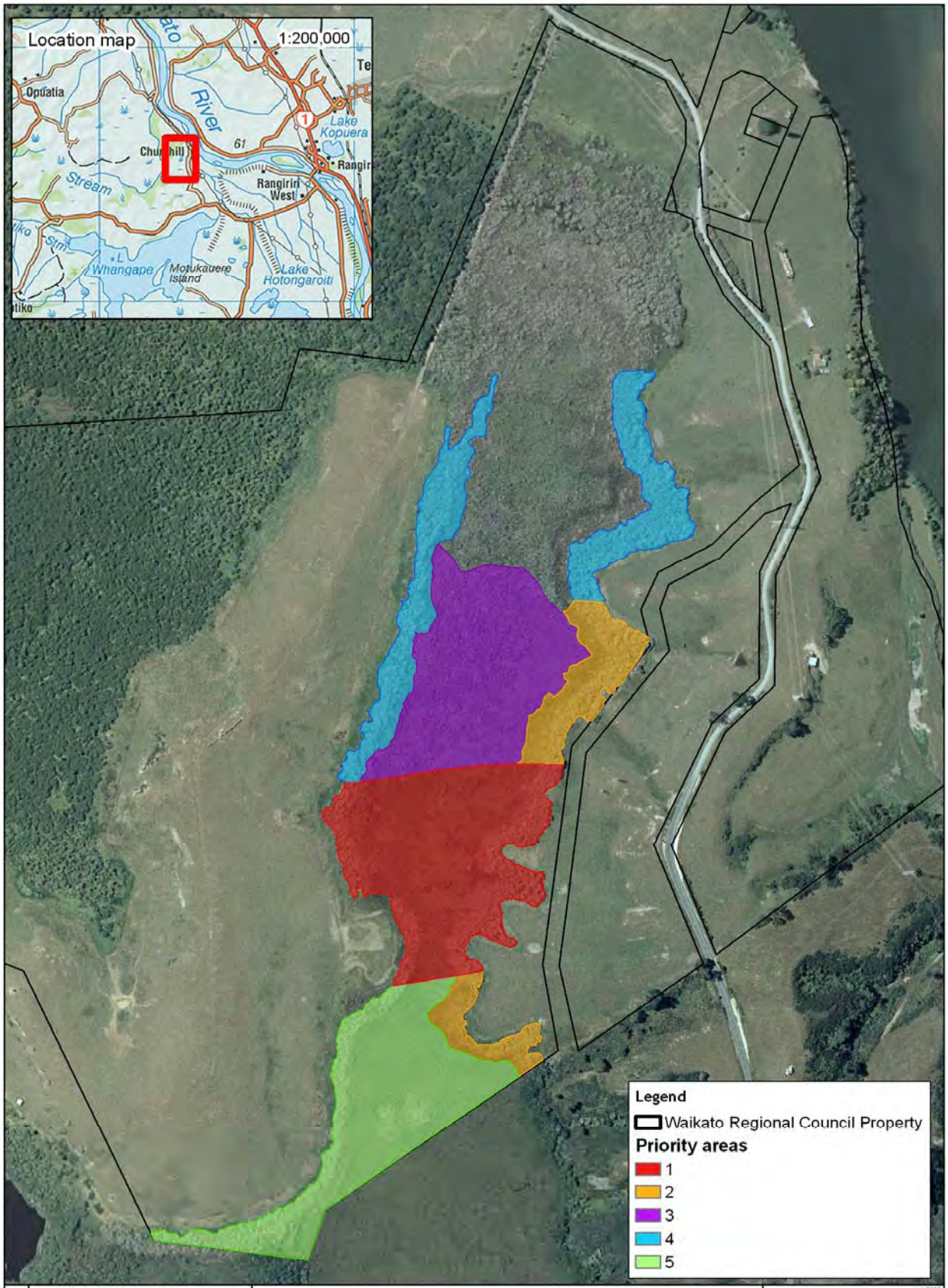


Figure 7. Priorities areas for weed control at the Waikato Regional Council managed peat bog at Opuatia Wetland.

Table 4: Description of priority areas for plant pest control.

Priority Area	Description of values and threats
1	This area contains some of the least impacted areas of fen and peat bog. The fen is particularly rich in indigenous species. The density and range of plant pest species is less than other areas of similar habitat.
2	Priority Area 2 is split into two areas of fen vegetation along the eastern margin of the peat bog. It is also rich in indigenous species. Unlike the western margin of the peat bog there is no gorse present. The main threat to this area is from grey willow saplings which could form a dense canopy that would diminish the abundance of indigenous species.
3	This area includes a large area of manuka scrubland and wirerush-tanglefern rushland, Unlike other areas of these vegetation types it contains very few plant pests.
4	Priority Area 4 is split into two areas of fen vegetation. These areas have a similar mix of indigenous species to priority area 2, however they contain a wider range of pest plants at greater densities.
5	This area contains a large area of valuable peat bog habitat bordered by fen along the western margin. While gorse is present throughout large parts of the wetland it is most abundant in this area and has proven difficult to eliminate.

In addition to the above it is suggested that plant pest control is undertaken in the 'indigenous vegetation plantings' (Figure 5). While not a priority for biodiversity protection, for relatively limited effort, it would aid indigenous canopy closure thus making it less vulnerable to future weed invasion.

Recommended methods for controlling plant pests are listed in Table 5.

Table 5: Recommended methods for controlling pest plants.

Pest Plant	Control Method	Timing	Comments
Alder	Bore cut and poison/stump swab larger specimens using Metsulfuron 5g/L. Foliar spray smaller specimens at full leaf stage with Metsulfuron or Tordon BK.	Feb-autumn	Important to carry out control at least a month after grey willow has set seed to prevent grey willow establishing in gaps.
Crack willow	As above.	Feb-autumn	As above.
Gorse	Foliar spray, either with gunsprayer or knapsack sprayer depending upon the situation. The isolated plants will most likely be controlled using knapsack sprayers. Various herbicides can be used including: Metsulfuron, Tordon BK, or Triclopyr.	Spring-autumn	
Grey willow	Bore cut and poison/stump swab larger specimens using Metsulfuron 5g/L. Foliar spray smaller specimens at full leaf stage with Green Glyphosate 510 - 110ml/10L.	Feb-autumn	Important to carry out control at least a month after grey willow has set seed to prevent reinvasion.
Reed canary grass	Foliar spray monospecific stands with Green Glyphosate at 1% plus penetrant. If there are desirable species close by use Haloxyfop 0.5% plus 0.5% crop oil.	Spring-autumn	A difficult species to control due to the thick rhizome mat. Will need repeated application.
Reed sweet grass	See above.	Spring-autumn	As above.
Royal fern	Foliar spray with Metsulfuron 3g/ 10L.	Spring-summer	
Yellow flag iris	Foliar spray with Green Glyphosate at 1% plus penetrant.	Spring-autumn	A difficult species to control due to the thick rhizome mat. Likely to need repeated application.

6.4 Nutrient enrichment

As WRC manages the land surrounding the WRC peat bog, there are a number of opportunities for reducing nutrient inputs. Grazing leases could include clauses to require good nutrient management practices and stating limits on fertiliser use, timing of application, and maximum stocking rates.

Fencing the wetland has created a buffer of tall grasses and herbs that will filter out excess nutrients in overland flows. The buffer however is very narrow (<1 m) along parts of the eastern margin, particularly where seeps enter the wetland. Most of the seeps are not fenced (only one had temporary fencing during the field survey) although they do retain some indigenous sedges. It would be beneficial to fence the seeps (Figure 8) and supplementary plant with additional sedges (Table 6).

Table 6: Planting schedule for seeps adjacent to the WRC peat bog.
Plant spacing: 0.5-0.75 m.

Species	Size	%
Carex gaudichaudiana	RTH	20
Carex subdola	RTH	40
Carex virgata	RTH	20
Baumea arthrophylla	RTH	20

6.5 Revegetation

Revegetation is only considered a priority in areas that are unlikely to regenerate naturally following weed control. These are the swamp margins of the wetland where there are high densities of reed sweetgrass, reed canary grass, and yellow flag iris (Figure 8). The indigenous species that currently occupy this type of habitat at Opuatia Wetland are mostly short, and unlikely to out-compete plant pest species. To reduce the need for ongoing plant pest control we recommend planting mainly shrubs in the damp/moist areas of this habitat (Table 7), and tall sedges and reeds in the permanently wet areas (Table 8). All revegetation species currently occur in the WRC peat bog and, if planted at the recommended densities, should achieve canopy closure within three years.

Table 7: Planting schedule for damp/moist swamp margins.
Plant spacing: 1.0-1.2 m.

Species	Size	%
Leptospermum scoparium	RTH	35
Coprosma propinqua	RTH	15
Coprosma tenuicaulis	RTH	15
Phormium tenax	RTH	20
Cortaderia fulvida	RTH	10
Cordyline australis	RTH	5

Table 8: Planting schedule for permanently wet swamp margins.
Plant spacing: 0.5 m.

Species	Size	Maximum Water Depth
Baumea articulata	RTH	- 0.6 m
Eleocharis sphacelata	RTH	- 1.3 m
Typha orientalis	RTH	- 1.0 m

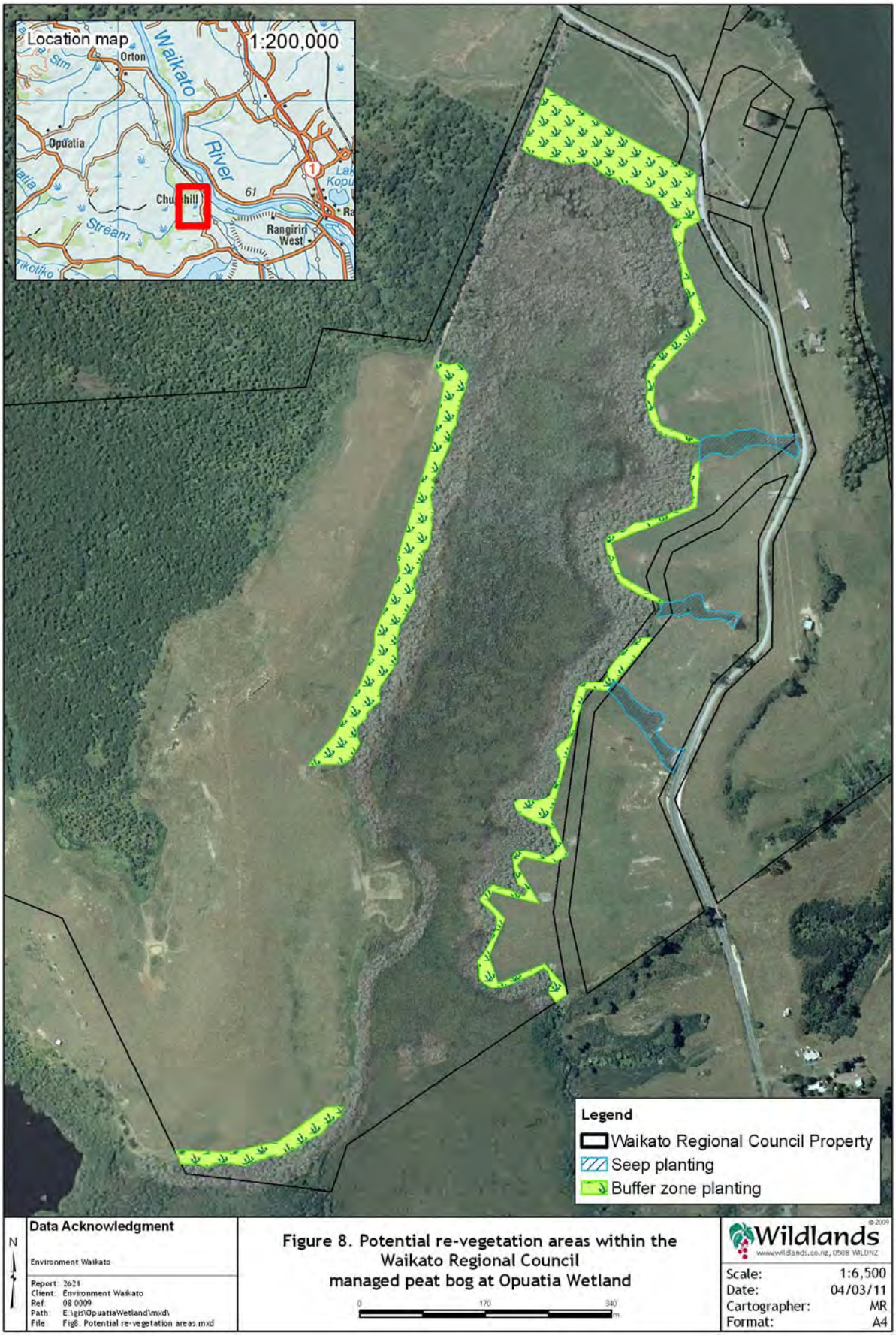


Figure 8. Potential re-vegetation areas within the Waikato Regional Council managed peat bog at Opuatia Wetland

7. IMPLEMENTATION AND MONITORING

An overview of tasks and a suggested timeline is provided in the tables below. Monitoring is linked to management actions.

Table 9: Management issues and actions in Years 1-2.
Priorities are indicated in the following way: H= high priority, M= medium priority, L= low priority.

Hydrology		Pest Animal Control		Weed Control		Nutrient Enrichment	
Task	**Timing**	**Task**	**Timing**	**Task**	**Timing**	**Task**	**Timing**
Year 1							
Decide whether to investigate hydrology further or remove all causeway culverts. **H**	As soon as possible	Control red deer within the Opuatia Wetland. **H**	Consult with DOC.	Apply herbicide to all known occurrences of royal fern. **H**	Spring-summer	Fence seeps on the eastern margin. **M**	
				Establish 4-8* photopoints in Priority Area 1 to monitor effectiveness and impacts of weed control. Estimate cover abundance of dominant species and weed species within a 5 m radius of the photopoints. **M**	Within a month prior to weed control.	Review grazing lease agreements and if necessary/ feasible add clauses to reduce nutrients reaching WRC peat bog. **M**	
				Apply herbicide to weeds (e.g. grey willow & gorse) in Priority Area 1. **M**	February-autumn		
				Control grey willow saplings in revegetation area. **H**	February-autumn		
Year 2							
Continue with hydrological investigations if this option adopted. **H**		Repeat red deer control unless satisfied that red deer numbers have been substantially reduced. **H**	Consult with DOC.	Check effectiveness of last years royal fern control and carry out surveillance for any new incursions. **H**	Spring-summer	Supplementary plant seeps if necessary. **L**	Spring
If culverts removed check to see whether this has caused dieback of gorse in the gorse infestations closest to the causeway that have not been sprayed. **M**	Spring.			Apply herbicide to all known occurrences of royal fern. If royal fern incursions >30 then abandon targeted control and control only as part of priority area control programmes. **H**	Spring-summer		
				Monitor Priority Area 1 photopoints. **M**	Within a month prior to follow-up weed control.		
				Respray any weeds not killed in Year 1 in Priority Area 1 and revegetation area. **M**	February-autumn		

* Number of photopoints will depend on resources available.

Table 10: Management issues and actions in Years 3-5.
Priorities are indicated in the following way: **H**= high priority, **M**= medium priority, **L**= low priority.

Hydrology		Pest Animal Control		Weed Control		Nutrient Enrichment	
Task	**Timing**	**Task**	**Timing**	**Task**	**Timing**	**Task**	**Timing**
Further hydrological investigation option: Assess whether management is needed and feasibility of options. Implement management if required. **H**		Continue surveillance of red deer every two years. **L**	Consult with DOC.	Check effectiveness of last years' royal fern control and carry out surveillance for any new incursions. **H**	Spring-summer	Infill planting of seeps if necessary. **L**	Autumn.
Culvert removal option: Check to see whether this has caused dieback of gorse and other weeds in areas close to the causeway that have not been sprayed. **M**	Spring	Consider setting-up programme to monitor mustelids to determine whether bird populations would benefit from a trapping programme. See King 1994 for guidance. **M**	Summer-autumn	Apply herbicide to all known occurrences of royal fern. If royal fern incursions >30 then abandon targeted control and control only as part of priority area control programmes. **H**	Within a month prior to weed control.		
				Monitor Priority Area 1 photopoints and determine whether the approach has been successful. If so set up same monitor - control programme in other priority areas. If approach has not been successful (i.e. continual weed reinvasion, decrease in cover of native species) reassess management approach including a do-nothing option. **H**	Same as above		

Table 11: Management issues and actions in Years 5-10.
Priorities are not indicated as these need to be determined following assessment of management actions in previous years.

Hydrology		Pest Animal Control		Weed Control and Revegetation		Nutrient Enrichment	
Task	**Timing**	**Task**	**Timing**	**Task**	**Timing**	**Task**	**Timing**
Further hydrological investigation option: Assess success of any management options implemented in Years 3-5.		Continue surveillance of red deer every three years.	Consult with DOC.	Continue surveillance and control of royal fern if occurrences still < 30.	Spring-summer		
		Continue with mustelid trapping programme if adopted in Years 3-5.		Assess the success of control programmes in priority areas in Years 3-5. If successful move monitor-control programme to non-priority areas. If gorse remains a problem then start with control in north and move south. All other weeds should be controlled from south to north.			
				Revegetation following weed control in swamp areas will be needed. Plant according to Tables 6 and 7.	Spring		

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Michelle Hodges (WRC) assisted in the field and provided information on past management activities at Opuatia Wetland. Dave Campbell (University of Waikato) provided climate data. Keith Thompson, Dion Patterson (Department of Conservation), and Willie Shaw (Wildland Consultants Ltd) all provided useful information on management aspects.

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INDIGENOUS VASCULAR FLORA OF THE WAIKATO REGIONAL COUNCIL PEAT BOG AT OPUATIA WETLAND

INDIGENOUS SPECIES

Gymnosperms

Dacrycarpus dacrydioides	kahikatea
Podocarpus totara var. *totara*	totara

Monocot. trees and shrubs

Cordyline australis	ti kouka, cabbage tree

Dicot. trees and shrubs

C. propinqua var. *propinqua*	mingimingi
C. rhamnoides	
C. robusta	
C. tenuicaulis	
Coprosma ×*cunninghamii* (*Coprosma* ×*propinqua* × *C. robusta*)	
Elaeocarpus hookerianus	pokaka
Epacris pauciflora	tumingi
Leptospermum scoparium agg.	manuka
Melicope simplex	poataniwha

Dicot. lianes

Muehlenbeckia complexa	pohuehue

Ferns

Azolla filiculoides	retoretore
Blechnum minus	swamp kiokio
Blechnum novae-zelandiae	kiokio
Dicksonia squarrosa	wheki
Gleichenia dicarpa	tangle fern
Microsorum pustulatum	kowaowao, hound's tongue fern
Paesia scaberula	matata
Pteridium esculentum	rarahu, bracken

Orchids

Microtis unifolia agg.	maikaika

Grasses

Cortaderia fulvida	toetoe
Isachne globosa	swamp millet

Sedges

Baumea arthrophylla	
Baumea articulata	
Baumea rubiginosa	
Baumea tenax	
Baumea teretifolia	
Carex gaudichaudiana	
Carex geminata agg.	rautahi
Carex maorica	
Carex secta	purei
Carex sp.	
Carex subdola	
Carex virgata	purei
Eleocharis acuta	spike sedge
Eleocharis gracilis	
Eleocharis sphacelata	giant spike sedge, ngawha
Gahnia sp.	
Isolepis distigmatosa	
Isolepis reticularis	
Tetraria capillaris	

Rushes

Empodisma minus	wire rush
Juncus planifolius	
Juncus prismatocarpus	
Juncus sarophorus	wi

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

Dianella nigra	turutu
Gahnia sp.	
Lemna minor	karearea
Phormium tenax	harakeke, flax
Sparganium subglobosum	maru, burr reed
Triglochin striata	arrow grass
Typha orientalis	raupo
Wolffia australiana	

Composite herbs

Euchiton limosus

Dicot. herbs (other than composites)

Centella uniflora	
Drosera binata	sundew, wahu
Hydrocotyle novae-zeelandiae var. *novae-zeelandiae*	
Hydrocotyle pterocarpa	
Lobelia anceps	punakuru
Myriophyllum propinquum	
Nertera scapanioides	
Persicaria decipiens	tutunawai
Ranunculus macropus	raoriki

NATURALISED AND EXOTIC SPECIES

Dicot. trees and shrubs

Alnus glutinosa	common alder
Berberis glaucophylla	
Crataegus monogyna	hawthorn
Salix cinerea	grey willow
Salix fragilis	crack willow

Dicot. lianes

Calystegia silvatica	greater bindweed
Calystegia sepium × *C. silvatica*	
Lonicera japonica	Japanese honeysuckle
Rubus cissburiensis × *R. ulmifolius*	blackberry

Ferns

Osmunda regalis	royal fern

Grasses

Agrostis capillaris	browntop
Agrostis stolonifera	creeping bent
Anthoxanthum odoratum	sweet vernal
Bromus willdenowii	prairie grass
Dactylis glomerata	cocksfoot
Glyceria maxima	reed sweetgrass
Holcus lanatus	Yorkshire fog
Lolium perenne	rye grass
Paspalum dilatatum	paspalum
Paspalum distichum	Mercer grass
Phalaris arundinacea	reed canary grass

Sedges

Cyperus congestus	purple umbrella sedge
Cyperus eragrostis	umbrella sedge
Isolepis sepulcralis	

Rushes

Juncus acuminatus	sharp-fruited rush
Juncus articulatus	jointed rush
Juncus bulbosus	bulbous rush
Juncus effusus var. *effusus*	soft rush, leafless rush
Juncus holoschoenus var. *multiflorus*	
Juncus tenuis var. *tenuis*	track rush

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

Iris pseudacorus	yellow flag iris
Landoltia punctata	purple-backed duckweed

Composite herbs

Achillea millefolium	yarrow
Bidens frondosa	beggars' ticks
Cirsium vulgare	Scotch thistle
Conyza bilbaoana	
Crepis capillaris	hawksbeard
Erechtites hieraciifolia	American fireweed
Gamochaeta purpurea	spoonleaf purple everlasting
Hypochaeris radicata	catsear
Jacobaea vulgaris	ragwort
Senecio bipinnatisectus	Australian fireweed
Sonchus asper	prickly puha

Dicot. herbs (other than composites)

Cerastium glomeratum	annual mouse-ear chickweed
Daucus carota	wild carrot
Epilobium ciliatum	tall willow herb
Epilobium ciliatum × *E. pallidiflorum*	
Galium palustre	marsh bedstraw
Geranium dissectum	cut-leaved geranium
Lotus pedunculatus	lotus
Ludwigia palustris	water purslane
Ludwigia peploides	primrose willow
Lycopus europaeus	gypsy wort
Lythrum hyssopifolia	hyssop loosestrife
Mentha pulegium	penny royal
Myriophyllum aquaticum	parrot's feather
Persicaria hydropiper	water pepper

Persicaria strigosa	
Plantago australis	swamp plantain
Plantago lanceolata	narrow-leaved plantain
Plantago major	broad-leaved plantain
Polygonum arenastrum	small-leaved wireweed
Prunella vulgaris	selfheal
Ranunculus flammula	spearwort
Ranunculus repens	creeping buttercup
Ranunculus sardous	hairy buttercup
Rumex acetosella	sheep's sorrel
Rumex obtusifolius	broad-leaved dock
Stachys sylvatica	hedge woundwort
Trifolium pratense	red clover
Trifolium repens	white clover
Veronica scutellata	